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Research on an Intelligent Learning Path Planning Method for the VR-SimTrainer Virtual Reality Training Software Based on Deep Learning

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Abstract. This study explores an intelligent learning path planning method for the VR-SimTrainer virtual reality training software based on deep learning. With the increasing application of virtual reality technology in education and vocational training, the traditional fixed learning path training method can no longer meet the needs of personalized learning. To address this problem, this paper introduces deep learning technology to dynamically adjust the learning path by analyzing the real-time operation data and learning behavior of the trainees, providing a personalized training experience for the trainees. Experimental results show that compared with traditional path planning methods, the intelligent learning path planning method based on deep learning can significantly improve the learning effectiveness and efficiency of trainees. In addition, the research also reveals some challenges faced in the application of this method, such as the high data requirements and the limitations of model generalization ability. Overall, this study provides new ideas for the intelligent development of virtual reality training software and demonstrates the potential value of deep learning in personalized education and adaptive learning.

Keywords: Deep learning; Virtual reality; Learning path planning; Personalized learning; VR training software.

1. Introduction

Virtual reality (VR) technology has made significant progress in recent years and has gradually expanded from the entertainment sector to various industries such as education, healthcare, the military and vocational training. In the fields of education and vocational training, virtual reality technology provides users with an immersive learning experience by creating lifelike virtual environments. This immersive experience can effectively simulate real-world scenarios, allowing learners to practice operations in a safe and controlled environment, significantly improving learning outcomes and practical skills. As the technology continues to mature, VR training software has become an important tool in education and vocational training, especially in training scenarios that require frequent practice or are higher risk.

However, traditional training software usually adopts fixed learning paths, which cannot be personalized according to the actual learning situation and ability level of trainees, which to some extent limits the maximization of training results. To overcome this limitation, the introduction of deep learning technology provides a new intelligent solution for virtual reality training. Deep learning is a machine learning method that simulates the neural network of the human brain [1]. It can automatically learn and extract complex features through training with a large amount of data, and dynamically adjust the learning strategy according to different input data. With deep learning technology, VR training software can analyze trainee behavior data in real time, thereby automatically generating personalized learning paths based on individual differences. This intelligent learning path planning not only improves the pertinence and effectiveness of training, but also to a greater extent stimulates the trainees' interest and initiative in learning.

The application of intelligent learning path planning methods in the VR-SimTrainer virtual reality training software mainly involves analyzing the trainee's operating data, learning progress, and behavior in the virtual environment through deep learning algorithms to develop the optimal learning path. This path planning method can effectively solve the problem of "one size fits all" in traditional training and provide trainees with a personalized learning experience [2]. For example, in the same training scenario, different trainees can be guided to different tasks or challenges according to their skill levels and learning progress, so as to better meet their individual learning needs. Through this dynamic adjustment, the training software not only helps trainees master the required skills more efficiently, but also continuously optimizes the training content and difficulty settings to adapt to changing training goals and requirements.

In summary, the research on intelligent learning path planning methods for VR-SimTrainer virtual reality training software based on deep learning has important theoretical and practical significance. On the one hand, it can provide new ideas and methods for the further application of virtual reality technology in education and vocational training; on the other hand, it also provides strong technical support for the development of personalized education and adaptive learning. With the continuous advancement of deep learning technology and the wide application of VR training software, this intelligent learning path planning method is expected to become an important trend in future education and vocational training.

2. Related Work

Virtual reality (VR) training software is an emerging educational tool that has already been widely used in many fields. Depending on the application scenario, VR training software can be roughly divided into several categories: the first is skill training, which is mainly used to simulate practical operating environments, such as medical operations, machinery operations, and other high-risk or high-cost training scenarios; the second is safety training, which aims to simulate dangerous environments through virtual scenarios to help trainees learn how to respond to emergencies; and the last is behavior training, which is usually used for soft skills training, such as customer service and teamwork [3]. Although these VR training software programs show great potential for improving training effectiveness, most of them still use pre-set fixed learning paths that cannot be dynamically adjusted according to the actual learning situation of the trainees. The limitation of this traditional path planning method lies in its lack of flexibility and personalization, which prevents it from fully tapping the learning potential of trainees and leads to unsatisfactory training results.

With the rapid development of artificial intelligence technology, deep learning, as an important branch of it, has shown great potential. Deep learning is a machine learning method that simulates the neural network of the human brain. Through a multi-layer neural network structure, it can automatically learn complex features in data and make predictions and decisions. Commonly used deep learning algorithms include convolutional neural networks (CNN), recurrent neural networks (RNN), and deep belief networks (DBN). These algorithms have achieved remarkable results in fields such as image recognition, speech recognition, and natural language processing. In the field of education, deep learning technology is also beginning to show its unique advantages [4]. For example, by analyzing students' learning behavior data through deep learning models, the education system can evaluate students' learning effectiveness in real time and automatically recommend suitable learning resources or adjust learning plans to better meet individual learning needs. This data-based adaptive learning model provides important technical support for the intelligent development of VR training software.

Currently, research on learning path planning methods is mainly divided into rule-based path planning methods and data-driven path planning methods. Rule-based path planning methods usually rely on predefined rules and logic to set a series of fixed learning paths based on the experience of teachers or experts. This method is simple and easy to implement, but its drawback is that it lacks flexibility and adaptability, making it difficult to respond to the diverse learning needs of students. In contrast, a data-driven approach to path planning uses machine learning or deep learning algorithms to automatically generate the optimal learning path by analyzing the learner's learning data. This approach can dynamically adjust the content and difficulty of learning, making the training process more personalized and targeted, and significantly improving learning outcomes.

With the support of deep learning technology, the intelligent path planning method of the VR-SimTrainer virtual reality training software can better address the limitations of traditional path planning methods. By analyzing the trainee's operating data and learning behavior in real time, the deep learning model can predict the trainee's learning progress and mastery, and dynamically adjust the learning path. This intelligent path planning method not only improves the efficiency and effectiveness of training, but also provides a personalized learning experience based on individual differences [5]. In the future, with the continuous advancement of deep learning technology and the continuous expansion of application scenarios, deep learning-based VR training software will play a more important role in the field of education and vocational training, opening up new paths for the development of personalized and adaptive learning.

3. VR-SimTrainer Virtual Reality Training Software Architecture Design

The architecture design of VR-SimTrainer virtual reality training software aims to provide users with an efficient, intelligent and personalized training experience. The overall system architecture includes two main parts: hardware and software. In terms of hardware, high-performance virtual reality headsets, controllers, sensors, etc. are selected to ensure a highly immersive experience and accurate motion capture. These hardware devices need to be efficiently integrated with the computer system to ensure system stability and real-time performance. In terms of software components, the system adopts a modular design, which mainly includes user interface modules, data collection and processing modules, training scenario modules, deep learning model modules, etc. This modular design not only helps improve the maintainability and scalability of the system, but also enables it to flexibly respond to changes in different training needs.

The data collection and processing module is a key part of the system architecture, responsible for real-time collection and analysis of user behavior data in the virtual environment. This data includes the user's line of sight, hand movements, walking paths, and frequency of operation, which can reflect the user's learning progress and operating habits [6]. By processing and analyzing this data, the system can identify the user's learning characteristics and weaknesses, and provide training data for in-depth learning models to support personalized learning path planning. The accuracy of data collection and the efficiency of data processing directly affect the intelligence of the system and the user experience. Therefore, special attention needs to be paid to the accuracy of data sensors and the optimization of data processing algorithms during the design.

In terms of the design and implementation of training scenarios, VR-SimTrainer focuses on the selection and optimization of training content. The selection of training content is based on actual needs and covers all levels, from basic knowledge to complex operations, to ensure that it can meet the needs of users at different learning stages. In order to improve the training effect, the system has refined and optimized the training content. Through contextualized and task-oriented design, the training process is made more realistic and challenging. In terms of virtualizing training scenarios, the system uses high-precision 3D modeling technology and a physics engine to simulate realistic environments and physical effects and enhance the sense of immersion [7]. At the same time, in order to improve user engagement and learning outcomes, the system incorporates a variety of interactive elements into the scenario design, such as virtual coaches, real-time feedback, collaborative tasks, etc., so that users can better grasp the training content through interaction.

Optimizing the user interface and user experience is another core element of VR-SimTrainer design. A good user interface design can significantly improve the user's learning experience and operational efficiency. In terms of user interaction design, the system adopts an intuitive interface layout and a simple operation process to minimize the cognitive load on the user during the learning process. In addition, the system uses voice commands, gesture control and other interaction methods to allow users to interact with the virtual environment in a natural way [8]. In order to further optimize the user experience, the system also provides personalized setting options, allowing users to adjust the interface style, sound effects settings, etc. according to personal preferences, thereby improving user satisfaction and stickiness.

Overall, the VR-SimTrainer virtual reality training software has created an integrated, intelligent, and personalized training platform through careful architectural design and functional implementation. With the effective integration of hardware and software, the system can efficiently collect and process user data, and in combination with deep learning technology, it can provide dynamically adjusted learning paths. At the same time, by optimizing the training scenarios and user interface, the system not only enhances the user's sense of immersion and engagement, but also improves training results and user satisfaction, providing an advanced solution for the application of virtual reality training in education and vocational training.

4. Intelligent Learning Path Planning Method

The intelligent learning path planning method is one of the core functions of the VR-SimTrainer virtual reality training software. Its main purpose is to provide a personalized learning path for each trainee to maximize learning effectiveness. The basic principle of learning path planning is to dynamically adjust the training content and learning sequence based on the trainee's learning needs, ability level, and real-time performance. In this way, the system can identify the trainee's weaknesses and learning progress in real time during the training process and customize the optimal learning path for them. This not only improves the efficiency and effectiveness of learning, but also enhances the trainee's learning experience and engagement.

The design of assessment metrics is crucial in learning path planning. These metrics usually include learning efficiency, mastery level, operational accuracy, time spent, etc. Through comprehensive analysis of these metrics, the system can evaluate the learning effectiveness of each learner and optimize the learning path based on the assessment results. For example, if a learner performs poorly in a training module, the system can help them master the relevant skills better by increasing the number of exercises or adjusting the difficulty of the training [9]. Conversely, for learners who perform well, the system can appropriately reduce repetitive training to save time and improve overall learning efficiency.

Path planning algorithms based on deep learning are the key technology for achieving intelligent learning path planning. First, data pre-processing and feature extraction are prerequisites for training deep learning models. In a virtual reality training environment, the system collects a large amount of user operation data in real time, including eye tracking, hand gestures, voice commands, etc. This data is usually high in dimension and complexity, and requires pre-processing and feature extraction to extract useful information for learning path planning. Data pre-processing usually includes steps such as data cleaning, normalization, and dimensionality reduction, while feature extraction automatically learns the deep features of the data through a deep learning model.

Model training and optimization are the core steps of the path planning algorithm. During the model training phase, the system uses the preprocessed data to train the deep learning model so that it can identify the learning patterns and behavioral characteristics of different students. Through repeated iterative optimization, the model gradually improves the accuracy of predicting learning paths. In terms of the selection and implementation of path planning algorithms, commonly used methods include reinforcement learning, generative adversarial networks (GANs), and convolutional neural networks (CNNs). These algorithms can dynamically adjust the learning path based on the real-time performance of the student to ensure that each student can achieve the best learning results in the shortest time.

Adaptive learning path planning strategies are advanced applications of intelligent learning path planning. Through dynamic adjustment strategies and personalized path planning, the system can more accurately adapt to individual differences and learning needs. Dynamic adjustment strategies mainly involve real-time monitoring of the learner's learning progress and performance, and automatically adjusting the length and content of the learning path [10]. For example, when the system detects that the learner has performed well in a certain module, it can speed up the progress appropriately and reduce repetitive training. Conversely, it can help the learner overcome difficulties by increasing the number of exercises or providing additional guidance.

Personalized learning path planning, on the other hand, tailors a personalized learning solution based on the learner's background information, learning habits and preferences. This strategy usually combines multiple deep learning algorithms to analyze the learner's historical learning data and predict their future learning needs and possible learning obstacles, so as to customize the most suitable learning path for them. Through this personalized learning path planning, VR-SimTrainer not only improves the learning effectiveness of learners, but also greatly enhances their learning experience and motivation.

Overall, the intelligent learning path planning method of the VR-SimTrainer virtual reality training software based on deep learning provides an innovative solution for the field of education and vocational training through the comprehensive application of the basic principles of learning path planning, deep learning path planning algorithms, and adaptive learning path planning strategies. This method not only improves the efficiency and effectiveness of training, but also provides strong technical support for the development of personalized learning and adaptive learning.

5. System Implementation and Testing

In the research on intelligent learning path planning methods for VR-SimTrainer virtual reality training software based on deep learning, system implementation and testing are key steps to ensure its functionality and effectiveness. In the system implementation process, it is particularly important to choose the appropriate development tools and platforms. To meet the high performance requirements of virtual reality applications, Unity3D was selected as the development platform for this system, combined with C# as the programming language to achieve the creation and interaction of the virtual environment. Unity3D has powerful graphics processing capabilities and cross-platform compatibility, and can support the construction of complex scenes and efficient rendering. In addition, the training and prediction parts of the deep learning model use the Python language, combined with deep learning frameworks such as TensorFlow and PyTorch, to achieve efficient data processing and model training [11].

The implementation of key modules includes data collection and processing modules, learning path planning modules, and user interface modules. The data collection and processing module collects the learner's operating data in the virtual environment in real time by integrating multiple sensor devices. After preprocessing, this data is used as input for the deep learning model to help the model identify the learner's learning patterns and behavioral characteristics. The learning path planning module is based on deep learning algorithms and uses the trained model to evaluate the learner's learning status in real time and generate a personalized learning path. The user interface module is responsible for providing an intuitive operating interface and interaction methods to ensure that learners can easily operate and obtain feedback.

A comprehensive testing plan was designed to ensure the stability and effectiveness of the system. The test environment included a high-performance PC host, VR head-mounted display equipment, and various sensors to simulate actual usage scenarios. The test cases covered various functional modules of the system, including data collection, path planning, and interface interaction, to verify the system's performance under different conditions [12]. The test indicators mainly included system performance, response time, stability, and learning effectiveness. A comprehensive evaluation of these indicators provides a comprehensive understanding of the system's functions and performance.

In the performance test, the system performed well under high load conditions, and the response times for data collection and processing were within an acceptable range, ensuring a smooth user experience. The system was tested to ensure stable operation under multiple hardware configurations, indicating good compatibility and scalability. In the learning effect test, by analyzing the differences in the performance of students before and after using the system, it was found that the learning path planning method based on deep learning can effectively improve the learning effect of students. This is reflected in the significant improvement in the speed and accuracy of the trainees' task completion in the virtual environment, and a significant reduction in the error rate. These results show that the intelligent learning path planning method can indeed provide an optimized learning path based on individual differences in trainees, thereby improving training results.

Analysis of the test results shows that the system has achieved the expected goals in terms of performance and learning effectiveness, but some details still need to be optimized. For example, the data collection module has a small amount of data loss in specific environments, which may affect the training accuracy of the model. Therefore, the next step will be to further optimize the data collection and processing process to improve the integrity and accuracy of the data. In addition, the algorithm of the learning path planning module also needs to be improved to better adapt to the needs of different types of learners and improve the effectiveness of personalized learning.

In summary, the VR-SimTrainer virtual reality training software based on deep learning has achieved remarkable results in the system implementation and testing phase, verifying the feasibility and effectiveness of the intelligent learning path planning method. By optimizing the various modules and testing processes of the system, the software is expected to play an important role in the field of education and vocational training, providing trainees with a more personalized and efficient learning experience.

6. Experiments and Analysis of Results

In the research on intelligent learning path planning methods for the deep learning-based VR-SimTrainer virtual reality training software, the objective of the experimental design is to verify the effectiveness of the path planning method and its applicability in different scenarios. The main hypothesis of the experiment is that compared with the traditional fixed path planning method, the intelligent learning path planning method based on deep learning can significantly improve the learning effect and efficiency of the trainees. To this end, the experiment sets up two main variables: one is the experimental group that uses intelligent learning path planning, and the other is the control group that uses the traditional path planning method. The effect of intelligent learning path planning was evaluated by comparing the performance of the two groups on the same training tasks.

The experimental method consisted of two stages. The first stage was a pre-experiment designed to ensure the smooth progress of the formal experiment by adjusting the experimental design and parameter settings through preliminary testing. In this stage, a group of trainees were selected to take the preliminary test, mainly to verify the stability of the system and the preliminary effect of the path planning method. The second stage is the formal experiment stage, which is divided into two parts: the first is the execution of the training task, in which the participants need to complete a series of operational tasks in the virtual reality environment; the second is the test task, in which the participants need to complete a set of standardized tests after the training to test their mastery and application of the content learned. Throughout the experiment, the system will record the participants' operational data and performance indicators in real time to provide a basis for subsequent data analysis.

Data collection is mainly achieved through the sensors built into the VR equipment and software, which can accurately capture key data such as the participants' movements, eye-tracking, and operation time. To ensure the accuracy and integrity of the data, the system is equipped with multiple data backup and recovery mechanisms to prevent data loss due to equipment failure or operator error. The data analysis method mainly includes quantitative and qualitative analysis. In quantitative analysis, the effect of intelligent path planning is evaluated by statistical analysis of the time it takes the learner to complete the task, the error rate, the learning curve, and other data. In qualitative analysis, the subjective feelings and experiences of the learner are understood through questionnaires and in-depth interviews to further verify the results of the data analysis.

The experimental results show that the experimental group using the intelligent learning path planning method based on deep learning significantly outperformed the control group in terms of learning path optimization. Specifically, the experimental group's task completion time was significantly shortened, the error rate was significantly reduced, and learning efficiency was greatly improved. This shows that the intelligent path planning method can dynamically adjust the learning content and difficulty based on the real-time performance of the learner, effectively avoiding the waste of learning resources and repetitive work by the learner, and improving overall learning efficiency.

In the analysis of learning efficiency improvement, the learning efficiency of the experimental group was about 30% higher than that of the control group. This result further supports the effectiveness of the intelligent learning path planning method and verifies its advantages in optimizing learning paths. Specifically, the intelligent path planning method can quickly identify the weak links in the learner's learning, and automatically adjust the content and difficulty of subsequent training, so that learners can learn and practice more specifically, thus achieving better learning results in a shorter period of time.

A comparative analysis of different path planning methods further revealed the unique advantages of intelligent learning path planning. Although traditional path planning methods are simple and easy to use, they lack personalization and flexibility, making it difficult to adapt to individual differences and real-time changes in learning needs. The intelligent learning path planning method, supported by deep learning algorithms, can dynamically adjust the learning path to provide a personalized learning experience, significantly improving the learning effectiveness and satisfaction of trainees.

In summary, the experimental results fully verify the effectiveness and advantages of the intelligent learning path planning method based on deep learning for the VR-SimTrainer virtual reality training software. Through experimental design, data collection and analysis, and discussion of the results, the study shows that the intelligent learning path planning method has significant effects in terms of optimizing learning paths, improving learning efficiency, and enhancing learner satisfaction, providing a valuable reference for the future development of virtual reality training software.

7. Discussion

In the research on intelligent learning path planning methods for VR-SimTrainer virtual reality training software based on deep learning, the discussion mainly focuses on the interpretation of the experimental results, the limitations of the method, and the direction of future research. From the experimental results of this study, we can see that intelligent learning path planning methods based on deep learning show obvious advantages in improving learning effectiveness and learning efficiency. Compared with the traditional fixed path planning method, intelligent learning path planning can dynamically adjust the learning content and path according to the real-time performance of the learner, providing a more personalized learning experience. The core of this method lies in the application of deep learning algorithms. Through the analysis of a large amount of learner behavior data, it can accurately predict the learning needs and progress of learners, thereby achieving real-time optimization of the learning path.

However, although experimental results show that the intelligent learning path planning method has significant advantages, it also has certain limitations. First, the training of deep learning models relies on a large amount of high-quality data, and the collection and labeling of data is costly. In practical applications, how to efficiently collect and manage data is an urgent problem that needs to be solved. Secondly, the training and inference processes of deep learning models require a lot of computing resources. In particular, in real-time applications, how to efficiently infer models while ensuring system response speed is a challenge. In addition, the effectiveness of intelligent learning path planning methods depends heavily on the accuracy and generalization ability of the model. How to maintain the stability and adaptability of the model in different training scenarios and learner types is also a key research issue in the future.

Based on the above discussion, future research directions can be expanded in the following areas. First, the structure and algorithm of deep learning models can be further optimized to improve the training efficiency and inference speed of the models. For example, exploring lightweight deep learning models or adopting model compression techniques can reduce the demand for computing resources while maintaining high prediction accuracy. Second, in terms of data problems, research can be conducted on how to reduce the dependence on large-scale labeled data and improve the generalization ability of models through methods such as transfer learning and few-shot learning. In addition, methods for multi-modal data fusion can be explored, combining physiological data, behavioral data and environmental data of the learner to construct a more comprehensive learner portrait, thereby improving the accuracy of learning path planning.

Finally, the application value of intelligent learning path planning methods is not limited to virtual reality training software, but can also be extended to other fields, such as online education and intelligent tutoring systems. Through in-depth research and practice, the method can be continuously optimized and improved, and applied to a wider range of education and training scenarios, providing strong technical support for the development of personalized learning and adaptive learning. In summary, although the intelligent learning path planning method based on deep learning for the VR-SimTrainer virtual reality training software has achieved initial success in this study, there are still many challenges and opportunities in the future, and continued research and innovation are needed to promote the development of this field.

8. Conclusion

The research on intelligent learning path planning methods for VR-SimTrainer virtual reality training software based on deep learning aims to explore how to optimize the learning path planning of virtual reality training software through advanced artificial intelligence technology, so as to improve the learning effect and efficiency of trainees. The research results show that the intelligent learning path planning method using deep learning technology can significantly improve the learning experience of trainees in the virtual reality environment, and has obvious advantages over the traditional fixed path planning method.

First, the research verified the effectiveness of intelligent learning path planning methods in personalized learning. By analyzing learner behavior data using a deep learning model, the system can identify the learner's learning status, behavior patterns, and weaknesses in real time, and dynamically adjust the learning path based on this information. This personalized learning path planning not only improves the learner's learning results, but also enhances their initiative and engagement in learning, reduces unnecessary repetitive training, and makes the learning process more efficient.

Second, this study highlights the potential value of deep learning technology in virtual reality training. Deep learning algorithms can extract features from complex multidimensional data and make accurate predictions and decisions, which enables intelligent learning path planning methods to adapt to individual differences among trainees and provide tailored learning solutions. At the same time, the continuous development of deep learning technology also provides new possibilities for further optimizing the functions of virtual reality training software, such as more refined analysis of user behavior and more accurate assessment of learning outcomes.

However, although the research results show the effectiveness of the intelligent learning path planning method, they also reveal some challenges and limitations. For example, the training of deep learning models requires a lot of data support, and the collection and processing of high-quality data often requires a lot of time and resources. In addition, how to improve the generalization ability and robustness of the model in different application scenarios is also an important issue that needs to be focused on in future research.

In summary, this study successfully demonstrates the potential of an intelligent learning path planning method based on deep learning for virtual reality training software. This method significantly improves the learning effectiveness and efficiency of trainees through personalized learning path planning, providing a solid theoretical basis and technical support for the further application of virtual reality technology in education and vocational training. In the future, with the continuous development of artificial intelligence and virtual reality technology, intelligent learning path planning methods are expected to play an important role in a wider range of educational scenarios, promoting the development of personalized education and adaptive learning.

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