Research on Equipment Virtual Training Evaluation

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Abstract. Virtual reality technology was once regarded as the leading force in the development of industrial technology in the future. However, the development of virtual reality technology has encountered a bottleneck period, and its future will attract attention. This article discussed the current technical bottleneck of virtual reality technology, summarized the causes, and analyzed the future development trend of the technology. In view of the shortcomings of the training effect evaluation in the equipment virtual training, the needs of virtual training evaluation are analyzed, an evaluation index system is constructed, and the evaluation system framework is designed. The research results can provide a theoretical reference for perfecting the equipment virtual training.

Keywords: Virtual training; Training evaluation; Evaluation system; Technical bottleneck.

1. Introduction
Virtual reality technology is a kind of system simulation. A simulation system creates and experiences a virtual world to generate a certain three-dimensional dynamic environment, so that the user's facial features can feel a pleasant experience in this environment [1]. This technology attracted attention in many fields, and once set off a wave of research and development.
The actual training of equipment has the problems of high cost, complicated operation, and high maintenance cost. Therefore, equipment virtual training is increasingly paid attention by countries. The virtual training system is a kind of safe, economical, and efficient equipment training method, which enables the trainees to conveniently operate and handle special training in the laboratory. It also facilitates the instructors to track and control the entire training process [2]. In the virtual training system, it is necessary to introduce an evaluation method to objectively evaluate the trainee's virtual operation level in order to more accurately grasp the realization of training goals[3]. This article studied the training evaluation in the equipment virtual training from three aspects: demand analysis, indicator system and system framework.

2. Technical Bottleneck and Development Trend of Virtual Reality Technology
Although the current development of virtual reality technology has encountered a bottleneck period, this move does not mean that the technology will completely fade out. Once the existing technical bottleneck is resolved, it will inevitably burst out more powerful development momentum [4]. This article summarized the current technical bottlenecks of the technology.

2.1. Unable to Achieve Large-scale, Multi-target, Accurate Real-time Positioning
At present, products based on virtual reality technology have higher positioning accuracy. The infrared laser on the virtual reality device scans the helmet or the receiver on the handle and generates multiple signals. Based on the difference between the receiver signal response time, the spatial position and
attitude angle of the virtual reality device can be accurately calculated. The refraction effect becomes more complicated, and the spatial position information obtained at this time will be deviated. If the environment has a large spatial range and a complex scene, the positioning capability of the virtual reality device will decrease accordingly. Multi-target positioning has become the mainstream demand for multiple people to participate in activities at the same time. Although the immersive experience of one person will make the facial features get a comfortable experience, it is difficult to form interactive communication with other people, and the emotional experience is naturally substantial reduced. Therefore, the current virtual reality technology cannot break through the positioning bottleneck of large-scale and complex scenes and the real-time sharing of multiple target data has become one of the main technical bottlenecks restricting the advancement and development of the technology.

2.2. Unable to Completely Solve the Dizziness Caused by Virtual Reality Technology
At present, all products developed based on the virtual reality technology have dizziness and eye fatigue, and the above situation is closely related to the scene content constructed by the virtual reality technology. Generally, the user's tolerance time for the virtual reality device is between 5min and 20min. If the constructed virtual scene and screen are relatively smooth, the tolerance time can be extended to several hours, but can not avoid dizziness and eye fatigue. The reasons is in the following: 
Firstly, the body move but the picture does not moved accordingly. Virtual reality technology must obtain the posture and translation information of the corresponding device to form a picture suitable for it. After the user's body moved, the corresponding viewing position and viewing angle must be changed accordingly, but it is difficult for the device to feel the mobile parallax at this time. As a result, the viewing picture is not adjusted, which caused the conflict between the brain optic nerve in processing vision and limb movement information. 
Secondly, the picture has moved and the body has not moved. The biggest disadvantage of virtual reality technology is of an extremely limited physical space range. When the constructed virtual picture changes rapidly, the body will also move correspondingly, but it is restricted by the range of motion space. The body does not move with amplitudes, resulting in which limb information and visual information are not coordinated, and the larger the amplitude of such picture changes, the more obvious the lag of the body's movement information. 
The road of innovation of any technology is not smooth. Although the current virtual reality technology has encountered the two technical bottlenecks above, the road of development is slightly tortuous, but the latter has endless potential for development. It is believed that more companies will invest in virtual technology in the real world in the future, and the existing technical bottlenecks will be broken eventually.

2.3. Development Trend of Virtual Reality Technology
Virtual reality technology has been applied in many fields. This article discusses development trend of virtual reality technology in the future from the following aspects.
Breakthrough progress will be made in the field of gaming. With the rapid development of the game industry, 3D games have become the mainstream trend in the future. Virtual reality technology is precisely the foundation and platform for building 3D games. Through the simulation and openness characteristics of virtual reality technology, many players are concentrated in one scene, which can undoubtedly further improve the immersion of the latter. Therefore, virtual reality technology will achieve more outstanding results in the field of games. 
The rapid rise of the virtual reality industry and the surge in the number of R&D personnel. Virtual reality technology can provide users with powerful facial features, and encourage the latter to enjoy the immersive experience. There are already ample signs that the virtual reality industry will rise rapidly, such as: virtual reality announcements published by Google; Infiniti and Omnivirt are allied to allow users to experience 360° panoramic driving experience. The above examples all indicate that the spring of the virtual reality industry. In addition, the development of any industry is inseparable from the support of talents. With the development of the virtual reality industry, the corresponding number of technical R&D personnel is bound to show a surge, which is of great significance for driving employment and creating more abundant social benefits.
3. Virtual Training Needs Analysis  
Implementing real-time and non-real-time assessment of training conditions is an important part of virtual training. Reasonable effectiveness evaluation methods can test the effect of training, improve training methods continuously, and improve the pertinence of training. The evaluation of the proposed training effect is mainly from two aspects: The effectiveness evaluation of the equipment system is from the micro level and the basis of the virtual training effect evaluation; The image response ability and disposal ability evaluation is from the macro level, and focus on training effect evaluation. The two aspects should meet the needs of the following three aspects.

3.1. Combining Real-time Reviews and Post-mortem Assessments  
On the one hand, the real-time comments during the training will impact on the subsequent training process directly, and problems can be found and corrected timely; on the other hand, the evaluation can also be enhanced to avoid false achievements and false results; post-mortem assessment is a systematic, complete and comprehensive analysis, and comparison can assess the rationality more objectively and fairly. Command operations throughout the training process are effective and timely, changing the past disadvantages of emphasis on form and result.

3.2. The Combination of Single Evaluation and Comprehensive Evaluation  
It standardizes the evaluation indicators and evaluation content, ensures the comprehensiveness and completeness of the evaluation, but also establishes a suitable evaluation model for each individual evaluation indicator, reduces the difficulty of establishing the evaluation model, and solves the problem that training evaluation has been stagnant at low levels Puzzles.

3.3. The Combination of Qualitative Assessment and Quantitative Assessment  
Quantitative analysis and evaluation can obtain the evaluation results with objective and fair data, which is convenient for analysis and comparison [5]. However, due to the particularity of the training content, some indicators involving human factors and strong subjectivity cannot be quantified, and only qualitative analysis can be adopted. Both are combined closely to make the results of training assessment more objective and accurate.

4. Construction of Evaluation Index System  
The evaluation index system is an objective reflection of the overall status of training and evaluation. During training evaluation, there are different evaluation objects and evaluation purposes. A scientific and reasonable evaluation index system is the key for the success of the evaluation. The evaluation index system of equipment virtual training is composed of several evaluation indexes. It is difficult to construct it. Under normal circumstances, the evaluation range and the number of evaluation indicators increase the complication of the modeling process, and distort the essential characteristics of the system. Generally speaking, the principles of evaluation index system are testability, dynamics, and simplicity independence, objectivity, comparability.

4.1. Construction Method  
To build a virtual training evaluation index system for equipment, it is needed to analyze the training objectives, find out the basic elements, and then analyze each element to determine its characteristic attributes and information sources. In order to simplify the indicator system, it is needed to classify, merge and screen the indicators [6]. On the basis of the initially determined index system, it is put into practice for testing, or experts are asked to make judgments to make it closer to the actual situation and meet the needs, and finally form a scientific and reasonable assessment index system.

4.2. Evaluation Index System  
After the construction process above, a virtual training evaluation index system for equipment can be obtained as shown in Figure. 1.
The entire evaluation index system is determined step by step. Specifically, it can be divided into six first-level indicators. They are command capability, maintenance capability, supply capability, management capability, defense capability and mobility, which correspond to the sixth main training directions considered by the major categories. Each first-level indicator can be further subdivided into several second-level indicators for further refinement. Taking the command capability indicator as an example, it can be divided into five parts: decision-making capability, information capability, control capability, collaboration capability and situation analysis capability. The specific content and direction of the evaluation can be further clarified and standardized. Finally, when implementing specific refinement scores, quantitative data support is required, so the second-level indicators are refined again, and each second-level indicator is divided into several third-level indicators with agreed value ranges in advance. Taking information capability as an example, it is divided into four three-level indicators: information acquisition rate, information timeliness, information accuracy, and information sharing rate. So far, the evaluation indicator system has been constructed. The indicators have clear meaning, clear classification, and are independent of each other. They complement each other and are indispensable. They can basically reflect the effect of equipment virtual training.

5. Framework Design of Virtual Training Evaluation System

5.1. Calculation Formula
In order to make the evaluation more intuitive and closer to people's general thinking, a percentage-based form of measurement is used. First, it is to calculate the weight of each indicator in the higher-level indicators, and get the mathematical expression of the simulated training results of the armored unit. The weight of each index is obtained by the pairwise comparison method in AHP [7]. The two indicators \( s_i \) and \( s_j \). The scaling methods for pairwise comparison are 1-9 scaling method, fractional scaling method, and exponential scaling method. When the accuracy requirement is not very high under a single criterion, generally the 1-9 scaling method is used in this article. The relative importance of \( s_i \) and \( s_j \) in pairwise comparison can be expressed by the value \( a_{ij} \) in Table 1.

| \( S_i \) vs \( S_j \) | \( a_{ij} \) |
|----------------------|---------|
| same important       | 1       |
| slightly important   | 3       |
| obviously important  | 5       |
| strongly important   | 7       |
| absolutely important | 9       |

When n indicators are compared in pairs, the judgment matrix A can be obtained.
After the feature vectors of the matrix $A_{mxn}$ are normalized, the weights of each index can be obtained ($\omega_1, \omega_2, \ldots, \omega_n$). Each second-level indicator also uses a percentage system. When evaluating results, it is the first step to find the weight of each second-level indicator relative to the first-level indicator, and find the score of the first-level indicator: $S_j = \sum_{j=1}^{n} S_j \omega_j$, and then according to the weight of each first-level index relative to the total index, and finally find the total score: $S = \sum_{j=1}^{n} S_j \omega_j$.

5.2. Index Weight Calculation

In order to obtain a reasonable index weight, the expert consultation method is used to evaluate the importance of various indicators in the virtual training for dozens of experts such as front-line commanders, college professors, etc., and then according to the 1-9 scale method to obtain further judgment matrix of virtual quasi-training evaluation index system in AHP algorithm [8]. Table 2 is obtained by statistical analysis.

| Table 2. The importance of each element of the virtual training $S$ |
|-----------------|---|---|---|---|
| $S_1$ | $S_2$ | $S_3$ | $S_4$ |
| $S_1$ | 1  | 3  | 2  | 4  |
| $S_2$ | $1/3$ | 1  | $1/2$ | 2  |
| $S_3$ | $1/2$ | 2  | 1  | 3  |
| $S_4$ | $1/4$ | $1/2$ | $1/3$ | 1  |

| Table 3. Judgment matrix for grade $S$ in Table 2 |
|-----------------|---|---|---|---|
| | $S_1$ | $S_2$ | $S_3$ | $S_4$ |
| same important | | | | |
| Median | | | | |
| slightly important | | | | |
| Median | | | | |
| Obviously important | | | | |
| Median | | | | |
| strongly important | $\sqrt{\bigcirc}$ | | | |
| Median | | | | |
| absolutely important | $\sqrt{\bigcirc}$ | | | |

The calculation of the index weight of the AHP algorithm can solve the eigenvector and maximum eigenvalue of the judgment matrix. The main methods are the root method, the sum method, and the power method [9-11].

By the root method, the eigenvectors are found as Table 3. $W=[0.1603, 0.4668, 0.0953, 0.2776]^T$, $\lambda_{\text{max}}=0.4031$, $CI=0.0104$, $RI=0.96$, Consistency ratio $CR = CI/RI = 0.0108 < 0.1$. It is in accordance with the consistency check.

5.3. The Score of Each Sub-indicator

For different indicators, the scoring method is different. According to the requirements of virtual training, the secondary indicators can be divided into the following categories.
To find the smaller and better indicators. For such indicators, an ideal minimum value $T_{min}$ and an acceptable maximum value $T_{max}$ can be determined according to the highest level that the trainers can be achieved, if the actual value of this index is $t$, then the score for this training is

$$S_{ij} = \begin{cases} 
100 & t \leq T_{min} \\
\frac{T_{max} - t}{T_{max} - T_{min}} \times 100 & T_{min} < t < T_{max} \\
0 & T_{max} \leq t
\end{cases}$$

To find the larger and better indicators. It’s similar to the method in equation above, an ideal maximum value $T_{max}$ and an acceptable minimum value $T_{min}$ are determined, if the actual value of this indicator during a training session is $t$, the score of this training session is

$$S_{ij} = \begin{cases} 
100 & T_{max} \leq t \\
\frac{t - T_{min}}{T_{max} - T_{min}} \times 100 & T_{min} < t < T_{max} \\
0 & t \leq T_{min}
\end{cases}$$

To find the moderate values. According to the highest level that trainers can achieve in virtual training, an acceptable minimum value $T_{min}$, an acceptable maximum value $T_{max}$, and a moderate value $T_{mid}$ are determined.

$$S_{ij} = \begin{cases} 
\frac{t - T_{mid}}{T_{max} - T_{mid}} \times 100 & T_{mid} \leq t < T_{max} \\
\frac{T_{mid} - t}{T_{mid} - T_{min}} \times 100 & T_{min} < t < T_{mid} \\
0 & t \leq T_{min}, t \geq T_{max}
\end{cases}$$

6. Conclusion

Based on the needs analysis of virtual training evaluation, this paper built an evaluation index system and designed an evaluation system framework, and finally get a solution for virtual training evaluation. On the basis of this program, multiple evaluation methods of "real-time simulation + post-mortem analysis + personnel scoring" can be introduced to design a comprehensive training evaluation algorithm, thereby overcoming the limitations of a single evaluation method and further increasing the credibility of the evaluation results degree.

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