Three Suggestions for Improving the Scene Construction of Action Simulation Training Systems

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Keywords: Simulation Training System, Scene Construction, Development, Intelligence

Abstract: Action simulation training systems are important tools for enhancing training quality and effectiveness in modern military training. The scene model construction module, as a foundational component, provides realistic combat scenarios, enemy threats, and situational displays in a 3D virtual environment, significantly improving trainees' realism and training efficiency. This paper presents an approach for building action simulation training system scenes, from the perspectives of demand-driven principles, future adaptability, and technical support, offering theoretical foundations and technical guarantees for the complex and ever-changing battlefields of the future.

1. Introduction

The complexity of modern warfare requires us to shift from traditional field training to more efficient, safe, and flexible simulation-based training methods. While traditional field training can provide certain practical experience, its high cost, significant safety risks, and limited training scenarios make it difficult to meet the demands for diversification and complexity. Therefore, establishing an efficient action simulation training system is key to enhancing combat effectiveness. A core component of this system is the construction of training scenarios, which, by providing realistic virtual environments, helps trainees conduct more authentic combat training.

2. Aligning with the Battlefield, Adhering to the Combat Realism Concept

2.1 Principles for Constructing Combat-Realistic Training Scenarios

The foundation for constructing action simulation training system scenes should follow the principle of "close to real combat, similar to real combat, simulating real combat, and in line with real combat." This requires the simulated scenarios to be realistic not only in terms of visual and sensory details but also in terms of tactical interaction, enemy-friendly relationships, and complex situations that reflect real-world emergency responses and tactical decision-making.

First, visual simulation technology and rendering effects play a critical role in determining the quality and authenticity of the scene. By continuously improving the precision and realism of training scenarios, simulation training can provide trainees with a more immersive experience and enhance the effectiveness of the training. The following characteristics are essential for constructing high-quality simulation training scenes[1]:

- **Normativity**: The simulated scene should strictly comply with relevant tactical, technical, and legal regulations, ensuring that the training process aligns with actual combat requirements. Adhering to normative principles reduces misleading training processes and prevents errors or improper learning.
- **Realism**: The simulation training scenario should authentically reproduce various elements of a battlefield environment, including terrain, weather, and enemy situations. Through highly realistic scenes, trainees can better understand and respond to real battlefield challenges.

  DOI: 10.25236/eeha.2024.026

- **Educational Value**: All training scenarios should be designed around specific training objectives, ensuring that trainees can engage in goal-oriented skill training and tactical exercises within the simulated environment. Educational value requires the scene design to be aligned with training needs, ensuring that each scenario effectively guides trainees at various levels.
- **Targeted Design**: The design of scenes should be customized according to the specific needs of different professional fields. Different training goals require different scenario settings. For example, driver training needs to simulate traffic environments and road conditions, while tactical command training needs to simulate enemy confrontations and decision-making.

2.2 Enhancing Scene Realism and Interactivity

To improve the realism of training, simulation training scenes should focus not only on external environmental details but also on interactivity. Interactivity means that the training system not only needs to present diverse battlefield information in real time but should also respond to the trainee's actions and decisions. The simulation training scene should feature adaptive capabilities, adjusting the difficulty and complexity of the scenario based on the trainee's performance and responses. This interactivity not only enhances the trainees' engagement but also improves their ability to respond to emergencies.

3. Adapting to the Future and Increasing the Level of Intelligence

The future battlefield environment will be complex and dynamic. This requires simulation training systems to not only replicate current battlefield conditions but also be capable of dynamically adjusting and adapting to future combat demands. The simulation training system of the future will become more intelligent, capable of dynamically adjusting scenarios based on real-time data.

3.1 Intelligent Scene Generation and Adaptive Adjustment

An intelligent simulation training system can generate scenes autonomously and adjust them adaptively through real-time calculations and learning. By employing big data analysis and artificial intelligence (AI) technologies, the training system can automatically generate complex combat scenarios and continuously adjust the training difficulty based on the trainee's historical data, real-time performance, and tactical decisions[2]. This intelligent training environment not only increases the diversity of training but also enhances the trainee's adaptability.

3.2 Designing Diverse and Complex Scenarios

To meet the demands of future combat, simulation training scenarios should not be limited to traditional tactical training. Instead, they should encompass a variety of complex battlefield situations. Future battlefields may present challenges such as extreme weather, asymmetric warfare, and cyber warfare. Therefore, simulation training systems need to have the ability to construct multi-layered and multidimensional scenarios.

- **The terrain layer** includes various types of terrain such as mountains, plains, plateaus, hills, basins, and cities, providing diverse training environments. Each terrain type should also include terrain details like surface elevation changes, vegetation, and water bodies, as well as terrain features like rivers, mountains, roads, and bridges. These factors can influence the choice and formulation of training strategies. Furthermore, special environments like urban ruins or mountain caves should be considered, as they require tailored combat strategies.
- **The weather layer** includes various weather conditions, including sunny, cloudy, rainy, snowy, and foggy weather. Different weather conditions affect visibility and training conditions, influencing the trainee's tactical decisions. Future training should also include extreme weather conditions such as sandstorms, thunderstorms, and extreme cold, helping trainees maintain effective decision-making and execution in harsh environments.

- **The role layer** simulates friendly and enemy personnel in the training environment, while the object layer covers training equipment, personnel supplies, and auxiliary facilities. The effect layer includes visual, auditory, and sensory effects, enhancing the immersion of the simulation training process.
- **The tactical layer** should also be designed to consider future combat environments that may involve high levels of informationization and network warfare. Training scenarios should incorporate elements such as cyber warfare and electronic warfare to train trainees on how to respond to informationized combat challenges.

3.3 Real-Time Evaluation and Feedback in Intelligent Scenes

Intelligent simulation training systems can evaluate a trainee's performance in real-time during training and provide personalized feedback through intelligent mechanisms. For example, the system can analyze the trainee’s decision-making process in different scenarios and automatically offer suggestions for improvement, helping them quickly master tactical techniques. This technology significantly improves training outcomes and learning efficiency.

4. Key Technologies Driving the Transformation

With the rapid development of cutting-edge technologies such as virtual reality (VR), augmented reality (AR), and visual simulation technology, scene construction in simulation training systems has entered a new stage. The following key technologies are essential for advancing the development of scene construction in simulation training systems:

4.1 Virtual Reality (VR) Technology

Virtual Reality (VR) technology generates three-dimensional virtual worlds through computers, providing realistic environmental simulations and interactive experiences. VR systems typically include hardware devices such as head-mounted displays (HMD), sensors, and handheld controllers, which allow trainees to interact with the virtual environment. In simulation training, VR technology enables trainees to experience battlefield environments firsthand, engage in operational training, and conduct tactical exercises. VR technology also offers unique advantages in the creation of specific environments, especially in training under extreme conditions, where it can simulate various complex combat scenarios and dynamically adjust scene content based on training needs.

4.2 Augmented Reality (AR) Technology

Augmented Reality (AR) is another cutting-edge technology with significant applications in simulation training. While closely related to Virtual Reality (VR), AR differs in that it integrates virtual information with the real world in real time, enhancing the trainee's perception and interaction with the physical environment. AR not only provides superimposed virtual objects but also displays and offers real-time data feedback, improving the effectiveness and efficiency of training. In simulated training environments, AR technology combines virtual information (such as text, images, sound, etc.) with the real world, allowing trainees to not only perceive physical information in the actual environment but also receive immediate feedback and guidance, demonstrating unique advantages in enhancing training effects and efficiency.

4.3 Visual Simulation Technology

Visual Simulation technology combines computer graphics and digital simulation techniques to achieve a highly realistic reproduction of the real world. By faithfully recreating natural environments, battlefield scenarios, and other complex scenes, it greatly enhances the immersion, realism, and interactivity of training. Visual simulation technology is not limited to the reproduction of static scenes but can dynamically simulate complex changes in the battlefield, such as terrain, enemy conditions, climate, and tactics, thus providing trainees with a realistic and interactive training environment. Through this technology, trainees can more intuitively understand tactical

layouts, improve their quick-response and decision-making skills, and achieve more efficient training objectives.

4.4 Sensor Technology

Sensor technology refers to techniques that detect and perceive external environmental or object characteristics through physical, chemical, optical, or mechanical means. Sensors can collect and record various types of data in real time, such as temperature, humidity, pressure, speed, position, light intensity, etc., and convert this data into electronic or digital signals that are transmitted to corresponding processing units for analysis and processing.

There are many types of sensors, classified according to the physical quantity they measure:

- **Temperature sensorse:**Measure the temperature changes of objects or environments.
- **Pressure sensors:**Measure the pressure changes of liquids or gases.
- **Light sensorse:**Detect changes in light intensity, ranging from simple photodiodes to complex image sensors .
- **Motion sensorse:**Detect the position, speed, and acceleration of objects.the temperature changes of objects or environments.
- **Biosensors:**Monitor human physiological parameters, such as heart rate, blood oxygen concentration, etc. the temperature changes of objects or environments.

Simulation training requires a high level of realism in environmental reproduction. Although traditional on-site training can provide real combat experience, it is difficult to meet the diverse and complex training needs due to cost, time, and safety risks. Sensor technology supports virtual environments by providing real-time data, allowing simulation training systems to operate in more dynamic and realistic training scenarios. It can monitor changes in the virtual battlefield, including enemy and friendly positions, terrain variations, and climatic conditions. By integrating real-time sensory data, training systems can dynamically adjust the battlefield environment, offering trainees more authentic and complex training situations. Sensor technology can also monitor the trainee’s physiological condition in real time, such as fatigue, stress, and pressure levels, using wearable devices like heart rate sensors or skin response sensors. This data can be used to adjust training intensity and help analyze the trainee's performance, further optimizing personalized training plans.

4.5 Artificial Intelligence (AI) and Big Data Technology

Artificial Intelligence (AI) refers to technologies that simulate human intelligence behaviors to perform tasks. It includes subfields such as machine learning, deep learning, natural language processing, and computer vision. The goal of AI is to enable computers to autonomously learn, reason, make decisions, and perform complex tasks without explicit programming.

Big Data technology involves processing, storing, and analyzing vast amounts of complex structured or unstructured data. It emphasizes the efficient acquisition, storage, analysis, and visualization of data to extract valuable insights.

AI and Big Data are mutually reinforcing. Big Data provides the rich data resources needed by AI, while AI extracts deeper value from Big Data through advanced algorithms. In simulation training, AI can be used to simulate complex battlefield environments and hostile behaviors, generating diverse tactical scenarios to help trainees improve their responsiveness. At the same time, trainees can experience realistic combat scenarios in virtual environments. Big Data can analyze the trainee’s performance during the training process, helping instructors create personalized training plans. The combination of these technologies allows training environments to not only be generated automatically but also dynamically adjusted and optimized based on the trainee’s historical performance and real-time data, enhancing the realism and challenge of the training.

5. Conclusion

Action simulation training systems, as an effective method for "pre-practicing warfare,"[2] offer trainees a more realistic and efficient training experience through virtual simulation, artificial intelligence, and big data technologies. High-quality scene construction not only provides trainees

with more complex and diverse combat environments but also helps enhance their rapid decision-making, emergency response, and tactical execution capabilities. As technology continues to advance, future simulation training systems will become more intelligent, customizable, and efficient. To better adapt to future combat needs, greater investment should be made in the theoretical research, technological innovation, and resource allocation for scene construction, driving the development of more intelligent and efficient simulation training systems.

References

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