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On the Application of Virtual Simulation in Teaching of Engineering Surveying and Mapping

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Abstract: Virtual systems aim to provide a virtual environment and intelligent interaction for building measurements. In the face of complex scene tasks, measurement process simulation and analysis can be completed in advance, so as to assist the actual construction. For the requirements in the virtual simulation teaching of surveying and mapping, the virtual measurement area and its corresponding surveying and mapping response methods are required. The paper presents 3-dimensional visual measurement area that makes the mapping and surveying works. In our experiment, we use the teacher platform that is a contemporary educational application based on cloud computing technology. It is a 3D digital curriculum possibility that integrates an interactive reading experience, multimedia learning materials, and learning aids. Based on the simulator process, we show an application of virtual simulation is a complex micro individual with prominent intelligent interaction characteristics in construction simulation scenarios, which has great research significance in both theory and practice. Taking this simulator prototype as an example, the paper comprehensively applies virtual simulation to carry out research on building key technologies. The paper presents the virtual simulation in teaching can improve students learning enthusiasm and learning efficiency in many ways such as teaching and learning.

Keywords: Virtual Simulation, Virtual Reality, Engineering Surveying

1. Introduction

Students involved in the architecture, engineering and construction disciplines are often faced with the challenge of visualizing and understanding the complex spatial and temporal relationships involved in designing three-dimensional structures. An evolving body of research traces the use of educational computer simulations to enhance student learning experiences through testing real-world scenarios and the development of student decision-making skills [1].

According to the characteristics of construction engineering practical teaching, the necessity of virtual simulation experiment in teaching can bring significant improvement to a sense of strangeness and curiosity of students that can harvest the best knowledge in practice.

Simulation under the technical support of simulation teaching model tries to break through the limit, through effective learning environment design, promote learners in innovation, problem solving, decision making, critical thinking, information literacy, teamwork, compatibility, capture tacit knowledge, self-management and sustainable development of higher-order ability can be effective [1, 2].

Just like cloud computing, big data and 3D printing, the definition of VR is also very popular nowadays, with a charming sense of technology and future. This kind of three-dimensional virtual world simulated by computer technology and hardware equipment has the characteristics of virtual reality and multiple perception, which can make users get an immersive experience and unlimited interactive possibilities, and make it a new expression carrier [3, 11, 12]. For the requirements in the virtual simulation teaching of surveying and mapping in engineering, the virtual measurement area, the corresponding surveying and mapping response methods are required. Then the case methods are applied to improve students' practical virtual training ability. Relying on virtual reality and multimedia technology, the real simulation of experimental teaching makes the practical teaching course efficient by solving complex cases, sharing teaching facilities, improve students' interest in learning.

2. Research Background

2.1. VR Development Background in the Information Age

In 1994, Burdea et al published the book Virtual Reality Technology (VRT), which summarized the three basic features (3I: Immersion, Interaction, Imagination) of VRT [3].

(1) Immersion: Immersion is presence, reality, computer hardware and virtual reality engine through simulation of realistic 3D scene. It simulates the user in the real world of real objects, make users immersed in the virtual environment.

(2) Interaction: Virtual reality system through various sensors and equipment (such as data gloves, sensor helmet, etc.) established in the visual, tactile, auditory and other aspects and multi-dimensional information environment. Interaction channel, allowing users to conduct dynamic and real-time interaction with the virtual environment, changed the traditional way of human-computer interaction. The user can control the behavior and status of the object in a virtual environment that can also feedback information to the user.

(3) Imagination: Imagination refers to when users are immersed in the virtual environment, they can imagine the experience and experience in the virtual environment, so as to get experience and inspiration [3].

Traditional system simulation technology establishes an object mathematical model. It always lacks simulation of human senses such as visual, touch, and hearing. Scientific research has proven that humans are much more receptive and understanding of sensory information than abstract information such as numbers and words [3]. Therefore, when using the system simulation technology, the virtual VR uses new features such as real-time display and real-time interaction, which can greatly enhance users' acceptance and understanding of the simulation process and results. The combination of the VR technology and the system simulation technology are not only greatly promoting the development of the simulation technology, but also are making the virtual reality technology. As a result of the combination, the VR technology becomes more practical.

2.2. Analysis of Virtual Reality Technology Development

VR technology can simulate and perform objects with high precision through immersion, interaction, and conceived 3D features. It can also assist users in conducting various analyses, providing an effective methodology to solve complex problems. Therefore, VR has been highly paid attention by many industries since the beginning of its development, especially some areas that need to consume a lot of manpower and material resources, as well as dangerous applications, such as the development of distributed virtual battlefield environment and Hubble maintenance and training system in military, aerospace and other fields. In addition to this, VR comes in industries and in sectors like public safety, industrial design, medicine, urban planning, transportation, and culture and education.

A wide range of applications have produced a huge economic and social benefits. In 1983, the United States implemented the SIMNET program, covering 11 bases in the United States and Germany, connected through a computer network for integrated training for various complex tactical tasks [3]. The DEPTH system, developed by the Armstrong Laboratory in the United States, uses virtual reality technology to realize the maintenance and guarantee analysis of the aircraft [4].

The automatic virtual environment laboratory in the United States, is a laboratory about 3 meters tall and equipped with multiple mirrors, projectors and three-dimensional audio and video equipment. It uses holograms to create a virtual reality environment, which mimics human visual, auditory, and tactile perception, and is a typical virtual reality system [5].

Blekinge Technical College in Karlskrona, Sweden, developed a virtual CNC machine simulation system using virtual reality technology [3]. Popa and others have developed the virtual reality technology using the virtual medical puncture simulation system, through which users can perform the practice of medical puncture surgery [6].

In studies, many developed models were tested and evaluated using an already available distributed simulation and demonstration environment for positioning indoors and outdoors. Several ground truth points were carefully measured to the sub-centimeter accuracy using a tachymeter. The tachymeter employs optical distance and angular measurements and uses differential GPS for initial positioning. One of models is the method performed by the Leica smart station (TPS 1200) was used for the above purpose [8, 14]. In this methodology, the sequential Bayesian positioning estimator that was used for evaluating the performance of our movement model.

3. Current Situation Existing in Practice Teaching

In the traditional experimental teaching mode, students are assigned to do experiments in groups according to the experimental topics and class time arranged by the teacher in advance. Therefore, experimental projects cannot be well matched with classroom teaching progress because the laboratory time is only at specific experimental time, so it is difficult to perform the experiments to students at any time. In general, the application of virtual simulation technology is more three-dimensional than the traditional teaching content in form [9]. It is a traditional discipline that has greatly evolved with the recent advances in the past two decades in new technologies such as Engineering Surveying, Hydrographic Survey, Remote Sensing, Land Surveying and Cartography [10-11]. In construction engineering, most experimental projects are confirmatory and lack of design and comprehensive experimental projects. Therefore, the current situation of penetrating the VR through real time simulation becomes the most effective teaching method under the guidance of teaching objectives.

3.1. Analysis of Current Situation of Applied Talent Training Environment

Regarding the studies, the current teaching model also faces some practical problems [7]:

(1) Practice, practical training and operation sites are limited, the teaching environment and scenarios are difficult to build, involving high-risk or extreme large-scale comprehensive scenarios;

(2) For the number of training operation equipment and other reasons, students can only contact and use measurement instruments and equipment at a specific time and specific occasions, and it is difficult to meet the needs of repeated practice and improve skills;

(3) The practical training content is boring, and the role positioning is not allowed. Usually, a single role repeats the operation, consuming a lot of time and energy, which makes the students lose their interest and passion in the practical training;

(4) It is difficult to standardize the practical operation assessment standard, and the assessment results are difficult to be effectively recorded.

The majors of surveying and mapping of geographic information related to ordinary colleges of higher learning and vocational colleges presents the social responsibility of cultivating industrial talents at all levels. Its principle goal is to cultivate students' ability to independently use various measurement instruments, to express them in the form of maps or data, and to solve all kinds of surveying and mapping problems in the actual production.

The teaching courses in the current surveying and mapping of geographic information requires a strong ability, high quality, skill and it can be an effective link of innovative talents. Therefore, universities started prioritize professional teaching reform through VR technology-based training.

3.2. Analysis of Learner's Situation of Applied Talent Training

The construction engineering experimental based talent training provides students to complete their learning in the process of solving practical problems, and students conduct self-evaluation and reflection through independent exploration. In the virtual labs of construction training, the students simulate the experiment in a "real" environment, analyze and solve the whole experiment in the process of simulation preview, and then they are easy to use the result in the physical construction field.

For learners, failure setting is often the forbidden zone such as equipment damage, personnel safety accidents of the experiment in the traditional experiment. In the virtual simulation environment, the artificial setting of the experimental parameters will not cause the damage of the equipment and the safety accident of the operator. Virtual simulation model allows students to experience the process of knowledge generation as scientists discover.

In the virtual simulation in engineering, for example, in construction experiment, failure setting and solving can improve students' curiosity in knowledge, increase their intellectual potential, promote students' motivation, acquire problem-solving skills.

In virtual simulation, learners can easily set up the fault in the virtual simulation test, which is not time-consuming. that the reform and construction of the college teaching system must adapt to it.

4. Methodology of Surveying and Mapping in Virtual Simulation Training

The navigation and alignment of angle measurement system could be carried out by laser measurements [13]. In this paper, we present 3-dimensional visual measurement area that makes the mapping and surveying works. The TPS-1200 full simulator is one of the most advanced Total Station in the market. TPS1200 Simulation is developed by Leica Geosystems AG and is used by 8 users of Software Informer.

TPS1200's precision angle-measurement system operates continuously providing instant horizontal and vertical circle readings that are automatically corrected for any "out of level" by a centrally located twin-axis compensator. In this experiment, we use Galaxy version was built in the digital map measurement training. The simulation is completely created in accordance with the real instrument 1:1.

4.1. Instrument Erection

The TPS-1200 simulator provides the cognitive, operation and erection functions of the equipment. Learners can choose and freely operate it and set up the equipment (Figure 1). We do experiments for angle and distance measurement, reflection, and automatic target recognition.

Figure 1. *TPS 1200 station.*

The total station is a surveying instrument that combines the angle measuring capabilities of theodolite with an electronic distance measurement to determine horizontal angle, vertical angle and slope distance to the particular point for surveying experiment (Figure 2). Coordinates of an unknown point relative to a known coordinate can be determined using the total station as long as a direct line of sight can be established between the two points. Angles and distances are measured from the total station to points under survey, and the coordinates (X, Y, and Z or northing, easting and elevation) of surveyed points relative to the total station position are calculated using trigonometry and triangulation [8].

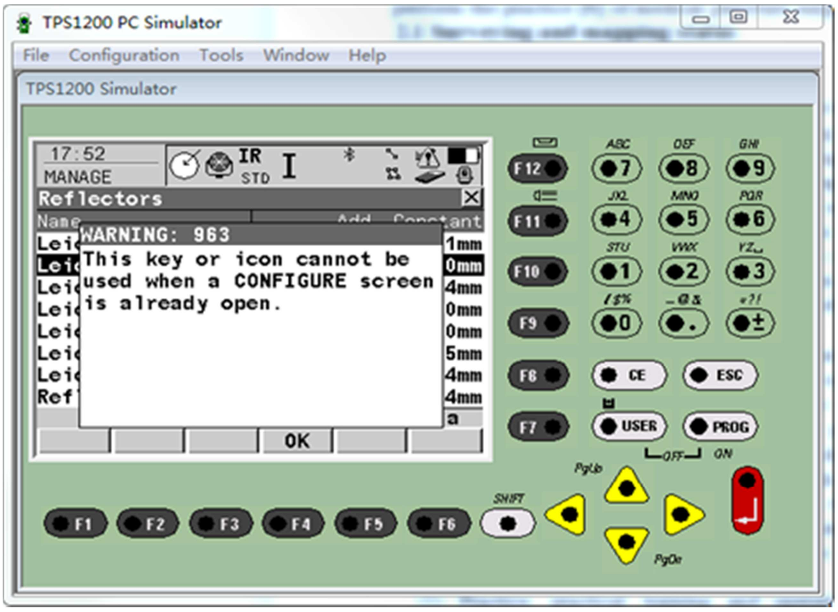

Figure 2. *TPS1200 Simulation face.*

To determine an absolute location, a total station requires line of sight observations and must be set up over a known point or with line of sight to two or more points with known location.

Figure 3. *Leica TPS1200 PC Simulator coordination.*

4.2. Virtual Measurement Area

To realize the application of virtual simulation technology in the practical teaching of engineering surveying and mapping, a virtual simulation system of architectural surveying and mapping is developed on the basis of desktop virtual simulation system [14].

The virtual environment established to avoid the risk of surveying and mapping is composed of the combination of digital models based on real data. A realistic three-dimensional scene strictly follows the standards and requirements of engineering project design, and truly "reproduce" surveying and mapping projects. Students roam arbitrarily in the three-dimensional scene, simulate the real space data, according to the active learning ability of teaching, learning and practice, independently complete the comprehensive virtual training operation, realize the smooth transition of students from classroom to after-curricular training, and complete the class assessment of students.

Figure 4. *Measurement area selection measurement point.*

4.3. Error Analysis of Virtual Simulation Experiments

In general, simulation error is described by the difference between a measured or calculated value of a quantities. In this case, the error value is determined through reference network that controls the detailed surveying. Whenever the test user passed across one of the ground truth points, the estimated position at that point was compared to the true position [14].

Measurement Errors

There are three types of errors: systematic errors, gross errors and random errors. Systematic errors are those errors which follow certain physical or mathematical rules. These kinds of errors are: calibration errors, tension in analogue meters, ambient temperature, etc. Those errors can be corrected by applying correction factors, calibrating instruments and selecting suitable instruments.

Accuracy

Accuracy is the degree of conformity with a standard or accepted value. Accuracy relates to the sum of the three interior angles of a plane triangle is 180°.

In addition, accuracy determines the value of a conventional unit as defined by a physical representation and true values of the control of detail surveying.

Precision

Precision is the ability to repeat the same measurement. In our case, we propose the sufficient values to determine the exact precision that is different from accuracy in that it relates repeatability of the measurements.

4.4. Simulation Area

Map matching in general is the concept in which tracking data are related to maps [15, 16]. The project area is the realistic three-dimensional scene (Figure 5). The reconnaissance of the experiment area or construction area has `been performed, and followed by establishing a network of control points of TPS 1200, which have been used for the detail surveying. In the established realistic three-dimensional scene, by simulating the instrument of the real space data, learners simulate the real measurement, complete a series of operations such as point selection, benchmark station construction, root point collection, data export transmission, prism erection, vertical micro movement, station construction setting, fragmentation measurement, data export drawing and so on.

Prism erection *Construction station setting*

Graph root point collection *RTK data export*

Figure 5. *Virtual simulation Experiments.*

4.5. Simulation Results

Data was processed in the respective software of the instruments. Data from the scanning was processed to realize the reading simulation, and the whole process records the training operation. The feedback tracks the correctness of the surveying and mapping process. The quality of the surveying and mapping results through recording and calculation. Learners can generate a training report on the operation results, for the scientific evaluation, scientific feedback and improvement plan. Teachers can also download the practice report of all students and the score of each exercise, understand the degree and shortcomings of the students, and make up in the actual teaching.

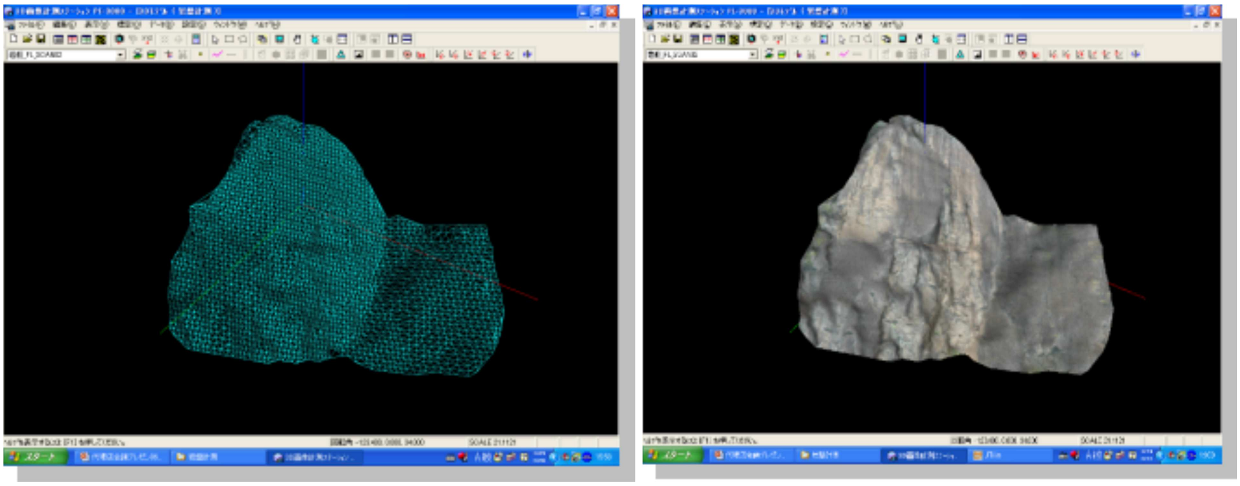

Figure 6. *3D scanning measurement and modeling results.*

4.6. Teacher Control Platform

In general, teachers conduct related theoretical teaching, they can upload relevant digital materials such as multimedia and video on the cloud platform, then students learn theoretical knowledge through the cloud platform [17].

Course control platform is a large-scale online three-dimensional experiential course platform that provides regular online learning services, including educational tools and training resources. In the teaching stage, the theoretical teaching form in the traditional teaching mode is still emphasized, and theoretical knowledge teaching is based on the corresponding textbooks, such as abstract concepts and difficult knowledge in theoretical knowledge [18].

In our experiment, the teacher platform is an advanced level educational application based on cloud computing technology. It is a 3D digital curriculum possibility that integrates an interactive reading experience, multimedia learning materials, and learning aids. On the basis of meeting the independent desktop operation experience, the course platform can flexibly, quickly and uniformly switch the operating system according to the needs of the actual teaching scenarios, so as to meet the application of a variety of teaching scenarios.

At the same time, the teacher provides the control function of the task control terminal. The background has the parameter part to control the emergency situation and change the assessment knowledge points. Finally, the behavior report of the students who complete the task is output to evaluate the students' mastery of the knowledge points in turn.

5. Conclusion

The paper presents the virtual simulation method in engineering practical teaching. The virtual simulation teaching method can overcome the shortcomings of traditional teaching methods in teaching abstract theories and principles. It can improve students' learning enthusiasm and learning efficiency. The virtual simulation training system proposed in this paper is not yet perfect, and the content of testing and setting has not yet been developed, however, the continued work in the virtual simulation is the future tasks for us. In addition, the best application of virtual simulation teaching in theoretical classrooms needs to be further explored in future education to improve students' understanding and practical skills.

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