Key technology of Laparoscopic Surgery Training System Based on Virtual Reality Technology

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Abstract. This study combines virtual reality technology with laparoscopic surgery training, based on the immersion, interactivity and imagination of virtual reality technology to provide doctors with new solutions for laparoscopic surgery, and quickly improve the use of laparoscopic surgical instruments by interns. The mastery of the laparoscopic surgical procedure is applied to the teaching, training and assessment of the intern, so that the intern can carry out the surgical training under the experience of being as close as possible to the real surgery, and improve the clinical technical level.

Keywords: Laparoscopic surgery, Virtual reality technology, Immersive experience, Surgery training

1. Introduction

In recent years, with the development of laparoscopic technology, the development of surgical treatment has been promoted. Surgical treatment with laparoscopic techniques can significantly reduce the incidence of postoperative complications and reduce the suffering of patients [1]. However, the characteristics of laparoscopic surgery technology determine that the learning curve starting point is higher than traditional open surgery, and the learning period is long [2]. In addition to the basic skills required for laparoscopic surgery, doctors need a simulated surgery that approximates the real operating environment to test the training results and beat basic skills. Virtual reality technology makes training more realistic, richer in content, and more ideal in training. It has become a research hotspot in the fields of medicine and computer[3]. In foreign countries, the Reachin’s Laparoscopic Trainer (RLT) developed in 2005 supports basic surgical skills training and cholecystectomy training, providing instructional surgical video, active guided student operation, and student self-operating functions [4]. The United States and Israel developed Simbionix in 2009. The image quality of this system is high, the model data comes from CT and MRI images of real patients. The system has a complete and continuous surgical procedure, and the physical interface can be inserted into real laparoscopic instruments [5]. At present, Beijing Liming Vision Company has launched a medical virtual simulation system solution in 2010 in cooperation with the General Hospital of the People's Liberation Army, which can provide interactive simulation training operations [6]. Tsinghua
University and Zhejiang University have obtained some preliminary research results, mainly focusing on three-dimensional reconstruction, which is relatively backward compared with foreign research.

2. Virtual medical care
Virtual reality technology is a technology that combines various scientific technologies such as computer systems, image display and sensors to perform human-computer interaction [7]. Since the advent of virtual reality technology, the virtual medical surgery model has been highly anticipated. The three characteristics of virtual reality technology, especially immersion, can be well combined with medical care [8]. Virtual reality technology can transform human medical images into 3D models, and observe the model on the screen like real surgery, operate the model, complete surgical learning, surgical training, and surgical rehearsal. Virtual reality surgery training can effectively avoid the traditional training mode of surgery. Limitations.

3. Virtual laparoscopic surgery system
The combination of virtual reality technology and laparoscopic surgery training can shorten the doctor's learning cycle and improve the quality of training. Moreover, the complex surgery with more operators can carry out simulation training and improve the overall level of the surgical team. The key technologies of the specific system construction include digital modeling, interactive realization and system integration.

3.1. Digital Modeling
For virtual surgery, it is one of the keys to improve the system immersion and effectively improve the efficiency of system training by providing realistic surgical instruments and geometric models of human organs, and accurately describing the hierarchical logic and physical properties of surgical instruments and human organs. Digital modeling mainly includes three parts: geometric modeling, dynamic modeling and physical property modeling [9].

3.1.1 Geometric modeling. This part of the work focuses on the shape and surface treatment of organs and instruments. The shape of the geometric model includes point location information and topology information connecting the points. Surface treatment can make the surface of the digital prototype object with realism. The surface treatment of the system mainly refers to the color texture map and the normal texture map.

3.1.2 Dynamic modeling. geometric modeling can obtain the static three-dimensional geometric properties of objects, but it is not enough to simulate real organs and instruments by geometric modeling. It also needs corresponding coordinates and corresponding angles between models, and also needs surgical instruments. The hierarchy is described. The tree structure of the surgical instrument facilitates the model to simulate various complex movements.

3.1.3 Physical property modeling. The use of physical engine is to describe the physical properties of the model, such as inertial mass, moment of inertia, surface friction coefficient, deformation modulus and elasticity. Only by combining the static and dynamic properties of the object with the physical properties can the design of the object in Unity3D and PhysX be completed in the most complete way.

3.2. Interactive Implementation
Place all motion capture, actual instrument containers, light sources, and motion servo devices in a closed box. Practical instrument container: Engineering plastic or metal tube that is as long as a laparoscopic surgical instrument. From the outside to the inside, there are five parts: a spherical joint, an instrument channel, a motion servo bracket, a tactile analog module and a switching device, and a virtual positioning device. The outer portion is connected to the outer wall of the box through a spherical joint, and the spherical joint has an opening for receiving a laparoscopic surgical instrument.
Most of the pipes are instrument passages and motion servo brackets. The motion servo bracket simulates the tension of the tissue in the abdominal cavity through the pneumatic link and the servo motor, and limits the displacement of the instrument through a plurality of links and maintains the spatial positioning of the instrument. The end of the pipe is a tactile simulation module (a hollow conical rubber bag with simulated jaw structure: the internal pressure is adjusted by an external hydraulic pipe and an electronically controlled piston to simulate the tension and toughness of the clamped tissue, and the liquid is simulated by suctioning the capsule Ultrasonic knife cutting tissue force feedback (simulating ultrasonic knife using foot control); continuous rubber ring conveying device with analog electric hook hooking tissue and cutting: rubber ring outer diameter about 6mm, inner diameter about 5mm, embedded in L-shaped metal groove Dozens of metal slots are stacked along the guide post and the guide rail slot and guided by the spring. The end of the guide post has an auxiliary electric hook oriented groove and an electric control blade for cutting the rubber ring, and is cut off while stepping on the electric hook to complete the cutting. The rubber ring is cut, and the module can also simulate the shearing of the scissors. The different types of tactile analog modules are connected to the actual instrument container through the nacelle. The different modules can be switched by rotation or placed side by side on the guide rail. The drive chain drives the switch. At the very end of the container is a virtual space locating device. Through special marking and computer vision positioning technology, the position of the instrument in the virtual space can be quickly captured in real time (the INTELRealsense real-life camera performs the displacement movement capture of the actual surgical instrument).

3.3. System Integration
A complete, laparoscopic surgical training system from the beginning to the end was developed based on the Unity 2018 engine reference laparoscopic surgery example. The Unity3D engine developed by Unity Technologies enables building visualization, real-time 3D animation, and virtual reality simulation. It is a multi-platform integrated game engine [10]. Unity3D can render the abdominal environment in a timely and accurate manner; the built-in NVIDIA PhysX physics engine system, real simulation of rigid body collision scenes; highly supported preset software collision animation; support for modifying Mesh mesh to simulate soft body deformation; support for naked eye 3D. In this system research, Unity3D supports the resource import of the reconstruction model, and the physical effects support the collision and interaction between the simulated instruments and the instruments, instruments and organs. Therefore, Unity3D was selected as the development engine to quickly realize surgical process simulation and soft tissue deformation in real time. The head performs the displacement movement capture of the actual surgical instrument).

3.4. Special effects settings
The reason why I chose Unity3D software during the project was because of its powerful special effects, which can make a variety of effects, the powerful particle system is relatively easy to get started, Unity3D shaders can make a variety Material, Unity3D can make a variety of special effects, many special effects are really amazing.

3.5. Performance Optimization.
The production of models is divided into two types[11]. One requires a very fine model and a very large number of faces. Try to simplify the model and improve the operating efficiency of the system. This model is very complicated. Another is a simple model. This model is made roughly, and the texture is used to achieve three-dimensional effects. The production of this model is very simple. There are also many specifications for the production of models. Considering the performance of the system, the requirements are very large. The number of faces of the model must be reduced to make the model. The maximum number of faces of a single model cannot exceed 1000. Otherwise, there are too many complex models in the scene, which will affect The operation of the system, the quality of the texture also affects the appearance of the model[12]. The texture is the most intuitive visual
perception of the model, so a good texture artist is very important. The model texture should be made as close to the Nth power pixel as possible. The operation will be very smooth. If the texture is irregular, it will affect the operating efficiency of the system. Delete the extra faces in the scene. When building the model, the invisible places need not be modeled. The invisible faces can also be deleted, mainly for improve the utilization of textures and reduce the number of faces in the entire scene to increase the speed of the interactive scene. The recommended minimum distance between model faces and faces is one thousandth of the maximum scale of the current scene.

4. Conclusion
The virtual laparoscopic surgery training system is developed based on virtual reality technology. The system can make the virtual environment produce various sensory sensations and high fidelity, allowing participants to complete laparoscopic surgery training under strong immersion. The virtual laparoscopic surgery training system can free the intern from the gauze practice, and the efficiency of the exercise is improved. On the other hand, it is not enough to get enough surgery just by repeating the training. There are information such as mistakes and inadequacies, and virtual reality can help the interns to practice the practical experience of the rapid accumulation process in the internship through data analysis and visual, auditory and other feedback mechanisms, and the advantages of immersion. With the development of computer graphics related technologies, it will play an increasingly important role in surgical training and related industries, providing new ideas for virtual surgery related research, with important economic benefits and encouraging applications. prospect.

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