Design and Implementation of Intelligent Tutor System for Training of Scalpel Operation

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Abstract: In order to improve the effect of knife-holding training and reduce the requirement of experimental environment, an intelligent tutor system for knife-holding training is designed and studied. The system can simulate the anatomy working scene, and has the function of intelligent recognition of scalpel holding technique and movement. It can also automatically complete the whole experiment teaching process, such as knife-holding training task layout, precise monitoring of training process, multimedia interactive training guidance, training result evaluation, educational administration management and so on. The experimental results show that the new design concept and practice method of the system are of great significance for reference and popularization.

Key Words: Experimental teaching, Scalpel operation training, New concept of design, Intelligent tutor system

1. Introduction

In order to enable clinical medical students to quickly and carefully grasp the use of scalpel, they can change the existing single experimental teaching methods and other issues. By expanding and innovating the design concept of the intelligent tutor system, this paper presents a design method of the intelligent tutor system for the skill training of scalpel operation. The experimental results show that the system can meet the requirements of the experimental teaching of scalpel operation training. The specific design of the system is discussed as follows.
2. Design concept of intelligent tutor system for scalpel operation training

At present, the unified definition of "intelligent tutor system" is: "An intelligent computer-aided instruction system that imitates the role of human teachers in teaching, provides personalized learning guidance for learners, and helps learners with different needs and characteristics to acquire knowledge and skills" [1]. Its basic functions are roughly as follows:

1) Be Able to explore the problem and give the solution process and tips;

2) It can construct and display the process of learners' knowledge acquisition;

3) Be Able to diagnose the learners' learning activities, their strengths and weaknesses and provide feedback to them;

With the development of artificial intelligence and microelectronic technology and the increasing demand of intelligentization in application, the basic function and design concept of intelligent tutor system are also expanding. Therefore, according to the intelligent demand of the application occasion, choosing new artificial intelligence technology and new device to display the distinctive personality, professional characteristics and delicate and perfect effect of the work is a new idea that the intelligent tutor system design must adhere to.

The experimental teaching of knife holding training is a kind of skill training teaching, which needs a unique training environment, training equipment and materials, as well as meeting the needs of group teaching and individual training. Its training methods should maintain the advantages and skills of tradition as well as the advancement of modern educational technology; its training process involves many teaching stages, such as the arrangement of training work, the monitoring and guidance of training process, the evaluation of training results, and the management of educational administration. Therefore, it is necessary not only to monitor and guide the training process accurately and in real time, but also to implement the scientific and automatic management of the whole teaching plan.

In order to design and implement the training intelligent tutor system, the following design work should be done as a whole:

(1) Setting up a simulation training environment. System equipment specifications, training methods should follow the original manual training environment requirements and meet personalized needs;

(2) Being able to follow the teaching requirements of knife holding training, and automatically implement the whole training teaching process and management;

(3) Scientific design of training methods. The method and plan of operation training should be combined with anatomy practice and classic operation cases;
(4) It can accurately monitor and guide the interactive operation of multimedia man-machine interface during scalpel-holding training;

(5) It can realize the scientific evaluation and guidance of training work and training result and the management of educational administration.

3. Design and discussion of the system hardware implementation scheme

The overall scheme of the system hardware must be designed and implemented according to the platform requirements mentioned above.

3.1 Overall structure of the hardware of a system

In order to ensure that the simulated training environment is similar to the actual training environment, the hardware structure of the intelligent tutor system is shown in figure 1. The system consists of a tablet computer and an intelligent analog scalpel, which are connected by wireless Bluetooth, and the tablet's touch screen doubles as a training tool. The intelligent analog scalpel adopts the handle style of No. 4 Scalpel, which is mainly responsible for the hand type, obliquity, force measurement, intelligent judgment processing and Bluetooth communication upload in the course of training. As the main controller of the system, the tablet computer is responsible for the monitoring, guidance and evaluation of the whole operation process.

3.2 Choice of tablet

At present, the function of tablet computer is perfect, and it is widely used as intelligent terminal in the field of automatic control. The basis of choosing the tablet computer as the main controller of the system is that, in addition to its perfect functions, high cost performance and good portability, its rich multimedia equipment, which can be developed for two times as the first choice. The functions of the system are realized by two application development of the touch screen function and the voice function of the tablet computer.

3.3 Function development of three-row cutter induction board

The Blade Sensor is a digital operating board that simulates the anatomy and surgical platform. It is an important input device that can sense the path of the blade. The tablet is equipped with a 10.1-inch capacitive touch screen, in addition to completing the function of graphics and text display, the use of capacitive touch screen monitoring function can achieve the function of knife sensor board. The system divides the capacitive touch display into two parts: row-knife operation area and parameter display area. The size of the operating area is $150\text{mm} \times 130\text{mm}$, which can detect the operating parameters of the scalpel such as knife-in, knife-in, knife-out, knife-out distance, knife-out time, and display the anatomical position map. The parameter
display area displays the training plan, the row knife parameter and the judgment instruction information in the form of text, color and graphic.

3.4 Simulation scalpel and its structure design

The analog scalpel is the key part of the system to realize the accurate monitoring. In the course of training, the hand type, strength and obliquity are measured, the hand type is recognized intelligently and the Bluetooth communication is uploaded. So the single-chip computer is selected as the intelligent controller [2], and the analog scalpel is composed of hand sensor, knife force sensor, knife inclination sensor, Bluetooth communication module, battery and charging circuit, which can be seen as Figure 1.

The structure of the knife handle and the arrangement of the components are shown in figure 2. The head a is a cutter head and a force sensing mechanism, which is composed of a movable engineering plastic cutter head, a spring chamber d, a magnetic core e at the cutter head end and a hall effect sensor h together to form a cutter force sensor. The tool holder b is an embedded circuit board, and the components on the board are micro-mount devices. The Hilt c is a hilt housing. To facilitate the wireless control of the tablet computer, the analog scalpel is powered by a miniature rechargeable battery.
4. Design and discussion of system software

The smart tutor system software is based on the Android platform[3] for tablet computers. Specific system software design considerations are as follows:

4.1 Function and structure of system software

The main functions of the system software are:

1) The realization of multimedia human-computer interaction interface and operation;

2) Real-time monitoring, intelligent processing, accurate guidance and evaluation of training results;

3) Training plan design editing, homework layout, marking and other educational management and database management.

The functional structure of the system software is shown in figure 3. The top half of the diagram is the interface structure of the software, showing the switching and affiliation between the various interfaces, the interface is responsible for direct interaction with the user. The lower half is the background structure, which controls and manages the data transfer. The Arrows in the diagram indicate the direction of the data transfer between the layers.

![Figure 3. Structure diagram of the system software](image)

4.2 Operation function and training method of system software

The main interface of the system has 2 working ports for teachers and students. The functions of the system are as follows:

1. Teacher side function
(1) Management of training questions and training achievement databases;

(2) Administration of Training Plan Design, training result correction, homework arrangement, etc.

2. Student End Function

(1) Four kinds of basic knife-holding training can be selected;

(2) Or choose operation knife training.

4.3 Method and process of knife-holding training

(1) Scalpel handling training. Through the skill training of knife-holding and knife-running, we can train the students to use the scalpel correctly and grasp the operating skills of the scalpel.

(2) The implementation process of scalpel handling training. The training of each method of holding a knife must go through training task arrangement, training guidance of holding a knife, knife training and monitoring guidance of training process. When the training task is completed, the improved DSC evaluation algorithm is used to evaluate the training result, then gives the training condition evaluation and the result to be recorded. In the whole process of scalpel-holding training, data display, voice prompt and other multimedia methods such as humanized prompt, monitoring and guidance.

5. Conclusion

The system test shows that the scheme of the system is novel and intelligent, which can meet the requirements of the training and teaching of knife-holding skills; The system’s lifelike training scene simulation and high-efficient and scientific training method not only replace the artificial experiment teaching, but also guide the students to complete the whole training teaching process in real time and accurately, and help the students to quickly master the practical skills; The systematic simulation training method and the scientific training plan can enable the students to experience the operating method directly and precisely, and obtain the expert's experience instruction; It can greatly improve the effect and efficiency of scalpel-holding training teaching. The design and practice of the system are of great significance to the reform of experimental teaching, the development of intelligent experimental equipment and the practice of the design of intelligent tutor system.

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