Construction and Design of Multimedia Virtual Simulation
Practical Teaching System of Ultrasound Image in Obstetrics

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Abstract. With the non-destructive, cheap, and real-time advantages, ultrasound diagnosis is one of the indispensable imaging diagnostic techniques in modern clinical medicine. The coherent nature of ultrasound imaging results in a low signal-to-noise ratio of ultrasound images, which adversely affects quantitative analysis and diagnosis. In practical applications, ultrasound diagnosis often has disadvantages such as the varying accuracy dependent on the doctor’s experience, the image feature extraction and analysis methods lagging behind the development of imaging technology, etc. Guided by the concept of “Mix of virtual and actual reality, multivariate cooperation”, the quality of experiment teaching in obstetrics and gynecology should be improved to achieve the experimental teaching goal of obstetrics and gynecology. In this paper, the necessity and characteristics of medical virtual simulation experiments are first analyzed. Subsequently, the construction of the medical virtual simulation experiment is expounded. Finally, how to carry out the experimental teaching of gynecology and obstetrics is summarized.

Keywords: Experimental Teaching of Gynecology and Obstetrics, Multimedia Virtual Simulation, Teaching Quality, Ultrasound Image

1. Introduction
Obstetric ultrasound diagnosis is an essential means to evaluate fetal intrauterine growth and development, which has considerable significance for reducing maternal and fetal mortality and ensuring eugenics[1-2]. In clinical obstetric examinations, measuring the lengths of various fetal diameter lines by ultrasound imaging to predict the fetal body weights is one of the crucial indexes for fetal intrauterine growth and development[3-4]. However, the accuracy of clinical fetal weight prediction is unsatisfactory mainly due to the random error caused by manual measurement of fetal size and the systematic error of regression analysis itself[5-6]. The following section is a detailed description of how to improve the quality of the experiment teaching of obstetrics and gynecology based on the medical virtual simulation experiment.
2. Necessity and Characteristics of Medical Virtual Simulation Experiment

Medical ultrasound is a discipline that studies the interaction between ultrasound and human tissues and applies it to medicine. It is a product from the combination of biology, medicine, acoustics, and engineering technologies. With the rapid development of electronics, computers, and other engineering technologies, ultrasound technology has been extensively applied in medical fields. Ultrasound diagnosis is an integral part of medical ultrasound. Its basic principle is to use the differences in acoustic characteristics of ultrasound in various tissues to identify and diagnose diseases through the images/signals formed by reflected echoes generated at the tissue interface. The propagation law of ultrasound in human tissues and the extraction of diagnostic information constitute the physical basis of ultrasound diagnosis. Ultrasound diagnostics includes principles, instrument construction, display methods, operating techniques, recording methods, as well as analysis and judgment of ultrasound information.

Compared with other medical imaging diagnosis methods, ultrasound diagnosis has non-destructive, painless, cheap, convenient, real-time, and other advantages. Hence, it has become one of the irreplaceable diagnostic methods in various clinical departments. On the other hand, due to the inherent features of acoustic imaging, ultrasound images have poor contrast and severe noise pollution. As a result, the features that characterize tissue characteristics are not evident in the images. Hence, compared with other medical imaging diagnostic methods, the accuracy of ultrasound diagnosis is relatively low and often closely related to the experience of the sonographers. For the better functioning of ultrasound technology in medical diagnosis, how to improve the quality and visibility of ultrasound images has become the goal of ultrasound imaging systems, and how to suppress noise effectively and enhance the accuracy of feature extraction in ultrasound images has become the goal of ultrasound image analysis.

3. Construction of the Virtual Simulation System of Ultrasound Image in Obstetrics

Software reliability modeling and simulation is to allocate the reliability index of the system to each component of the system, determine the reliability quantitative requirements of each component, to ensure the reliability index of the whole system. Two methods of reliability and cost design are proposed: RCCM and bcmm. The system reliability is a constraint, and the reliability of each component is calculated under the condition of minimizing the system cost, to help the system decision-maker allocate resources to each component reasonably. On this basis, the software reliability modeling and simulation problem is simplified to the optimization objective model based on the cost function, and the objective function can be written as the function of each component reliability

\[
\begin{align*}
\text{Min } \text{cost} & = \sum_{i=1}^{n} \text{cost}(r_i) \\
\text{s.t. } & \text{RE} \geq \text{RE}_0, \\
& 0.5 < \tau < 1, \\
& \text{RE}_0 = 0.9.
\end{align*}
\]

Where \(\text{cost}\) represents the total cost of the software system, \(r_i\) represents the reliability of the ith component, \(\text{RE}\) represents the reliability of the software system, \(\text{RE}_0\) represents the expected reliability value of the system to be achieved. Based on the equation (2), the expected reliability of the system
can reach 0.9, and the reliability of each component meets the minimum cost on the premise of 0.5 to 1. The constraint equation is added to the objective function as a state transition matrix term, which becomes an unconstrained optimization problem, namely:

\[ \text{Min cost} + \text{penalty} = \sum_{i} \text{cost}(r) + k \cdot \min\{0, RE - RE_0\} \] (2)

Where \( k \) indicates that if the lowest reliability value of the system is not satisfied, the state transition matrix is inversely proportional to \( RE - RE_0 \).

In general, in the model with the minimum cost as the optimization objective, the functional relationship between the cost and the reliability of each component is very important. The reliability cost relationship function based on experience and/or data is shown in equation (3):

\[ c_i(R; f_i, R_{i,max}) = e^{-\frac{(R-R_{i,min})}{R_{i,max}-R_{i,min}}} \] (3)

4. Simulation and Result Analysis
From May 2019 to August 2019, 12 pregnant women in need of induced labor were randomly selected to participate in the trial, and all participants voluntarily signed the informed consent. Among them, 8 pregnant women required medical induced labor because of fetal organ development abnormality or fetal chromosome abnormality, 1 pregnant woman required induced labor due to her own serious thyroid function abnormality, the other 3 pregnant women required induced labor due to social factors (no fertility index), and another pregnant woman with placental implantation during caesarean section at 39+3 weeks also participated in the trial.

Ordinary single 2D imaging was performed, and the placenta presented a relatively inhomogeneous echo area. The echo intensity of the whole placenta was relatively consistent, and there was no noticeable echo difference. It was impossible to distinguish the fine structure of the placenta. After the contrast agent was injected, there was a significant difference between the high and low echo in the placentas of the contrast image. The perfusion time of the contrast agent in the areas with rich blood supply was short, the duration was long, the echo was strong, and the blood supply was relatively high. The perfusion time of contrast medium in the weak part was relatively long, the distribution of contrast medium was less, and the echo was relatively weak. The difference in the perfusion time and the contrast of echo strength allowed clear presentation of the fine structure of placenta, through which the structure and blood supply of placenta lobule could be roughly determined (as shown in Figure 1).
When the contrast medium is injected, the placenta shows significant hyperechoic, but the fetal part has no visible change.

In the trial of postoperative patients, the clinician diagnosed the placental implantation during the operation, the pathological report 3 days after the operation suggested the placental implantation. The contrast test was performed 4 days after the operation, when the normal sonogram showed no abnormal echo of myometrium. The contrast between the echo of uterine cavity and myometrium was not visible, the echo of the whole myometrium in the contrast image was enhanced, and the contrast between the echo of myometrium and the echo of uterine cavity was distinct. The results suggested that when the probe was moved, there was a triangle abnormal echo area near the endometrial line of the myometrium. The internal echo intensity was different. The edge was hyperechoic and continuous with the endometrial line. The rest of the myometrium was still slightly hyperechoic. Combined with the pathological diagnosis of the patient during and after surgery, it was considered that the triangle abnormal echo area was probably the placental implantation site, as shown in Figure 2.

In the shadow mode, the boundary between placenta and myometrium is apparent.
5. Application of Medical Virtual Simulation Experiment to Improve the Experiment Teaching Quality of Obstetrics and gynecology

During the development of gynecology and obstetrics experimental teaching activities, to further improve the quality of experimental teaching, attention should be paid to the sharing of central resources between schools based on the establishment of a medical virtual simulation experimental platform to meet the needs of students in experimental learning better. Firstly, to truly implement the virtual simulation experiment teaching network sharing and promote the autonomous learning behavior of students at any time and place, special cost of more than 10 million yuan should be invested in server procurement to replace the original backward network equipment and create an excellent network sharing environment. Secondly, to improve the quality of gynecological and obstetrics experimental teaching by using the medical virtual simulation experiments, a laboratory management system should be designed according to the principles of informatization and intelligence. The system is mainly responsible for experimental course processing, student reservations, laboratory opening, and experimental teaching. When the students access the platform through the user login portal, they can view the dynamic sharing of some experimental teaching courseware and teaching results of gynecology and obstetrics anytime, anywhere. Among them, the introduction of the female pelvis focuses on the female pelvic structure, pelvic boundary, and bony landmarks. In the introduction of female genitalia, the focus is the external genitalia, internal genitalia, internal genitalia, and adjacent organs. After the students have mastered some basic knowledge through animation viewing, they are tested by random check to see if they can correctly identify the pelvic structure, etc., and guide them to summarize an experimental report. Subsequently, prenatal examination skills training is taken as an example. This part of the experimental teaching content can be prepared into a virtual project to show students in an animation form throughout the prenatal examination. To understand the fetal size, presentation, amniotic fluid, etc., the pregnant woman's hands are first put at the bottom of the uterus to measure the height of the uterus bottom. Next, the pregnant woman's hands are placed on the left and right sides. Gentle press examination is performed with one hand to determine the fetal limb position. Then, the right thumb of the pregnant woman is separated from the other four fingers to clarify whether it has entered the pelvis. Finally, the pregnant woman's hands are placed on both sides of the exposed part of the fetus, deep press is performed at the entrance of the pelvic bone to determine the extent of the presenting part.

6. Conclusions

It can highlight the people-oriented teaching concept and enhance the cultivation of innovative spirit and creativity in students. It is also conducive to changing traditional teaching concepts, developing more experimental teaching resources in obstetrics and gynecology, providing students with more subject learning materials, and allowing students to complete the study of relevant knowledge points with high efficiency in an open environment where experimental teaching resources are shared, thereby laying a sound foundation for future work practice. At this point, to improve the quality of experimental teaching in obstetrics and gynecology, it is necessary to implement the teaching concept of “Integration of virtual and reality, multivariate collaboration”, to establish a medical experimental teaching center based on virtual simulation. Through the improvement of the experimental teaching system and the distinct characteristics of the virtual simulation experimental teaching, an excellent
experimental teaching atmosphere for obstetrics and gynecology is created to achieve high-quality teaching.

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