Application of Virtual Simulation Technology in Biotechnology Experiment Teaching

Wei Chen(✉) and Zhikai Gan(✉)

Nanchang Institute of Technology, Nanchang 330044, Jiangxi, China
gyx84562@163.com, zhc010314@163.com

Abstract. Experiment is the key link of biology and an important means to cultivate students' practical ability and innovation ability. In order to stimulate students' interest in learning and reduce the risk and cost of experiments, virtual simulation technology can be used in the teaching of biotechnology experiments. This paper deeply analyzes the advantages of virtual policy technology, and explains the current way of building human models with the support of AnyBoby software. Using simulation software, the movement of muscles, bones, joints, etc. of the human body can be reproduced through three-dimensional images. Important for scientific research.

Keywords: Virtual simulation technology · biology · experimental teaching · application

1 Introduction

In the experimental teaching in colleges and universities, students can acquire knowledge through the selection of experimental objects, experimental design, observation of experimental phenomena, and analysis of experimental results, and have a more intuitive and comprehensive understanding of theoretical knowledge. There is a close relationship between experimental teaching and personnel training. Students can experience the fun of innovation in the experimental teaching and stimulate their enthusiasm for learning. With the continuous deepening of teaching content in college teaching, some scientific research results are introduced into experimental teaching. Factors such as long experimental period, expensive consumables, dangerous reagents and other factors will affect the experimental teaching in colleges and universities. After virtual simulation technology entered the field of education, these problems will not appear. Students conduct experiments through virtual simulation system, which has low cost and high safety factor. Therefore, virtual policy technology has received more and more attention in college teaching. Biology, as a highly experimental subject, requires students to actively carry out experimental operations. The virtual policy technology can simulate the movement of cells, the movement of the human body, and the reaction between chemical agents on the computer. It is a good science and technology for the teaching of biotechnology experiments, which can improve the teaching efficiency and improve the knowledge system of students.

Z. Zhan et al. (Eds.): ICBDIE 2022, AHCS 5, pp. 74–80, 2023.
https://doi.org/10.2991/978-94-6463-034-3_10

2 Virtual Simulation Technology

Simulation virtual technology is a computer-aided engineering technology that developed rapidly with the development of computer technology in the 1980s. Virtual simulation technology is to use models to reproduce the real situation of real life [1]. Virtual simulation technology generally simulates the motion of mechanical systems, or simulates dynamics and statics, and so on. The research object of simulation technology is mechanical system. A mechanical system is a combination of multiple interconnected components that can move relative to each other. The human body is also a mechanical system [2]. Virtual simulation technology has had a great impact on scientific experiments. In the past, scientific experiments generally required researchers to pass various attempts in the laboratory. In the process of trying, dangerous situations may occur, and virtual simulation technology can implement experiments on a computer [3]. This kind of simulation experiment can reduce the cost of the experiment and improve the safety of the experiment, which is a good technology for scientific research. The construction process of virtual simulation technology is probably that the designer builds a model on the computer, analyzes various dynamic performances of the model, and then improves the actual experiment according to the mechanical kinetic energy in the system, reducing the loss in the actual experiment process. With the help of virtual policy technology, some researchers adjust in advance in the virtual simulation system before conducting actual experiments, and the success rate of experiments is greatly improved [4].

Virtual simulation experiment teaching is a new experimental aid in the field of education today. Virtual simulation experiment teaching can use multimedia and the Internet, through the virtual policy experiment software produced by Flash or 3D technology, and use human-computer interaction to achieve the goal of conducting experiments on a virtual platform [5]. The purpose of presenting and learning is to make up for the defects in practical teaching. In the virtual policy experiment teaching, firstly, the students should be taught the principle and application of the experiment, and then the students should be simulated in the virtual simulation experimental platform, and finally, the students should be allowed to practice in the real workshop or laboratory [6]. This kind of experimental teaching based on virtual simulation technology can help students to be familiar with the experimental operation in advance, and improve the success rate of students in the actual experimental process [7].

3 The Benefits of Virtual Simulation Technology Used in Biotechnology Experimental Teaching

Virtual simulation technology can introduce the latest research progress in biology into the experimental classroom. In biology majors, the exam will show students some new literature materials or scientific research results. If you only rely on the teacher's dictation and research on the literature, it is impossible to deeply understand the biological structure. The teacher must look for simulation models on the Internet [8]. In the classroom, some new theories and new knowledge are explained to the students according to the movement of the creatures in the simulation model, and the students can more

clearly understand the specific principles of this scientific research achievement and the direction to be applied in the future.

Virtual simulation technology can solve the problems of too abstract theoretical knowledge and long experimental period in biological experiment teaching [8]. In the relevant investigation and research, it can be found that 91.53% of students believe that Flash interactive experiments can solve the difficulties encountered in traditional experimental teaching and reduce the error rate of experimental operation. In the virtual simulation experiment using 3D technology, it can be operated in 360°, imitating the experimental environment and objects of the height policy, and realizing the experimental projects that cannot be completed by the real experiment or have high risk and high cost, as a supplement to the real experiment. Due to the particularity of biological materials, some biological experiments have a long period, and only some life phenomena or developmental processes are displayed in biological experiments, and most of them are fragmentary and discontinuous. The transformation of some cutting-edge scientific research results into experimental teaching content is often difficult and complex, requiring the use of expensive large-scale scientific equipment [9]. Some micro-level experimental phenomena and experimental principles are relatively abstract and difficult for students to understand. In the process of transforming scientific research results into factory applications, some process systems are very complex and costly, and some technologies need to be kept secret. All these reasons prevent students from participating in the whole process of biological experiments, let alone master key technologies. As an important supplement and extension of real experiments, virtual policy experiments ensure the systematicness and comprehensiveness of biological experiments, and at the same time have low cost. The advantage of high security. The combination of virtual simulation experiment and traditional real experiment can promote students to broaden their horizons and obtain more systematic and comprehensive skills training [10].

The shared platform in the virtual simulation system can not only satisfy the experimental teaching of students at school, but also provide strong technical support for the continuing education of relevant teachers, the professional skills training of biotechnologists, and the popularization of biological knowledge in an efficient and convenient manner [11].

4 Human Modeling Process

The modeling of the human body in biology is based on multibody dynamics, in which the interactions and motions between parts of the human body are found. At first, the Doti dynamic model could only assume that the femur, tibia, foot and other parts of the human body were non-deformable rigid bodies. In recent years, with the development of computer technology, the degree of freedom of the simulation of human motion has gradually become more complicated. In the human body model, the connections between human joints are usually defined as frictionless ball-and-socket joints, hinges or universal joints, and the mechanical performance of muscles is usually described by the Hill model. Inverse kinematics or forward kinematics are often used when using models to simulate human motion [12]. Inverse dynamics is the process of determining muscle force, joint force and joint torque based on kinematic data and inertial characteristics of moving

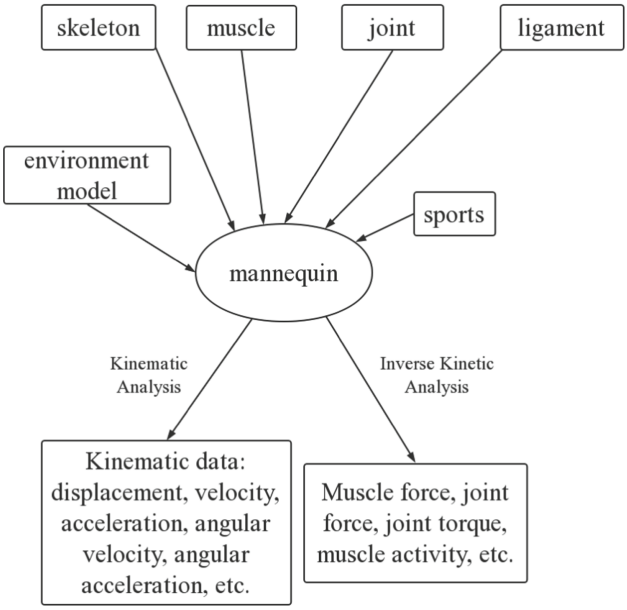

Fig. 1. AnyBoby simulation process

individuals. Forward dynamics uses equations of motion based on muscle force and joint torque data to determine the motion of various parts of the human body. At present, the software commonly used in human body modeling include SIMM, OpenSin, AnyBoby, MSMS and so on. This study uses AnyBoby, a software that can perform mechanical and dynamic numerical analysis on the human body's non-moving state [13].

AnyBoby can generate corresponding skeletal muscle models according to different human characteristics. In the absence of specific human data, AnyBoby uses the default ScalingStandard function to provide it to the user. When accurate human anatomy data is available, the user can autonomously code to scale the mannequin with a software-provided scaling function or a custom scaling function for the user to perform a specific study. The AnyBoby software builds models of the human body and environment using the programming language AnyScript. Mathematical expressions are used as an inherent factor in the AnyScript language. By using mathematical expressions in the model, the model can be parameterized and the model can be flexibly modified. AnyScript can also handle scalars, matrices, vectors, and tensors of arbitrary dimensions.

Users can define parameters such as bones, muscles, joints, ligaments, and drives of the human body model through programming language, and the software will solve physiological parameters such as the force of human bones, maximum muscle activity, and muscle expansion and contraction through inverse dynamics (Fig. 1).

When building a comprehensive human model, the first step is to build a skeletal model. The skeletal model is constructed using the start and end point muscle model, which is the start and end point of the muscle bundle going straight through the muscle. In the model, each bone is set as a rigid body that cannot be deformed, regardless of

Table 1. Anthropometric data of a patient

Human parameters	patient
gender	male
height	1.80 m
weight	60 kg
femur length	0.420 m
Pelvic width	0.160 m
thigh length	0.423 m
calf length	0.412 m
foot length	0.210 m

elastic or plastic deformation, each bone has a center of mass and a moment of inertia, simulating the inertial characteristics of the bone. To construct a skeletal model, it is necessary to measure the length of the femur, the width of the pelvis, the length of the thigh, the length of the calf, and the length of the foot, and then the skeletal shape of the human body can be roughly obtained (Table 1).

There are three ways to build the muscle model of the human body in the AnyBoby software, namely the simple muscle model, the binary linear muscle model and the ternary muscle model. Simple muscles do not consider the relationship between muscle force, length, and speed. The only input parameter is F0 of isometric strength, that is, under static conditions, assuming that the muscle can exert the force of F0 at the optimal length, F0 and the physiological transverse direction of the muscle. Proportional to the cross-sectional area. The binary muscle model assumes that muscle strength, current length, and contraction velocity are proportional, with sodomy first elastic. In the two-hospital muscle model, the contractile element and the serial elastic element are very critical. The ternary muscle model is the mature Hill muscle model developed in your home. In this model, the parallel passive elasticity of the muscle, the serial elasticity of the tendon, the feather angle of the fiber and so on are considered. In the ternary muscle model, some physiological parameters need to be referenced so that the model is more accurate. When building a human muscle model, you can choose a parametric model according to your own needs.

5 Conclusion

With the development of science and technology such as virtual simulation technology, image processing technology and computer analysis technology, the construction of human body model has become more convenient. In the past, in order to analyze the detailed structure of the human body, it was only possible to draw and reproduce the physiological state of the human body through anatomy. Now, the physiological state of the human body can be analyzed on the computer through simple measurements, which is convenient for biological experiments and research. There are also a wide range of applications.

References

1. Gonçalves Antónia, Estevinho Berta N., Rocha Fernando. Methodologies for simulation of gastrointestinal digestion of different controlled delivery systems and further uptake of encapsulated bioactive compounds [J]. Trends in Food Science & Technology, 2021, 114.
2. Park Juyeon, Ogle Jennifer Paff. How virtual avatar experience interplays with self-concepts: the use of anthropometric 3D body models in the visual stimulation process [J]. Fashion and Textiles, 2021, 8(1).
3. Wu Ying, Liu Jikun. Research on college gymnastics teaching model based on multimedia image and image texture feature analysis [J]. Discover Internet of Things, 2021, 1(1).
4. Dan Rui, Shi Zhen. Dynamic simulation of the relationship between pressure and displacement for the waist of elastic pantyhose in the walking process using the finite element method [J]. Textile Research Journal, 2021, 91(13–14).
5. Jijin Xie, Bin Liu, Yongling He, Xiaopei Zhang, Yuan Zhuang. Teaching Reform of Electronic Courses Based on Virtual Technology [J]. International Journal of Social Science and Education Research, 2021, 4(7).
6. OrtegoIsasa Iñaki, Rezola Ainhoa, Gao Yue, Chen Xiaodong, Valderas Daniel. Minimum Representative Human Body Model Size Determination for Link Budget Calculation in Implanted Medical Devices [J]. Applied Sciences, 2021, 11(13).
7. Singh Harpreet Pal, Kumar Parlad. Developments in the human machine interface technologies and their applications: a review [J]. Journal of medical engineering & technology, 2021, 45(7).
8. Tsveov Mihail, Dantchev Daniel, Kotev Vladimir. Improved 3D biomechanical model for evaluation of mass and inertial parameters in few body positions from NASA classification [J]. Vibroengineering PROCEDIA, 2021, 38.
9. ArráezAybar Luis A, GarciaMata Ricardo, MurilloGonzález Jorge A, delaCuadraBlanco Crótida, GómezMartínez Ana, BuenoLópez José Luis. PHYSICIANS' VIEWPOINTS ON FACULTY ANATOMISTS AND DISSECTION OF HUMAN BODIES IN THE UNDERGRADUATE MEDICAL STUDIES [J]. Annals of anatomy = Anatomischer Anzeiger: official organ of the Anatomische Gesellschaft, 2021, 238.
10. Ernesto Borges Batista, Luis Alberto Escalona Fernandez, Kirelis Napoles Dominguez, Yamila Ochoa Sarmiento, Claudia del Carmen Pupo Marrero. Dimension Fractal in Radiological Imagery for Comparison of Data Between Morphologic and Pathological Elements [J]. Applied and Computational Mathematics, 2021, 10(2).
11. Xiaojun Zhang. Physical training mode using deep learning and computer modeling and simulation technology [J]. International Journal of System Assurance Engineering and Management, 2021 (prepublish).
12. Gierczycka Donata, Rycman Aleksander, Cronin Duane. Importance of passive muscle, skin, and adipose tissue mechanical properties on head and neck response in rear impacts assessed with a finite element model [J]. Traffic injury prevention, 2021, 22(5).
13. Lüsebrink Falk, Mattern Hendrik, Yakupov Renat, AcostaCabronero Julio, Ashtarayeh Mohammad, OeltzeJafra Steffen, Speck Oliver. Comprehensive ultrahigh resolution whole brain in vivo MRI dataset as a human phantom [J]. Scientific data, 2021, 8(1).