Research on 3D Digital Skull Reconstruction Experiment Teaching

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ABSTRACT The skull complex plays an important role in the field of criminal investigation. However, because of its strong professional and technical characteristics, it is rarely used in the teaching of physical evidence in the comprehensive university law school. In order to be able to introduce and demonstrate of this technology to the students on normal law major, the experimental team used of laboratory equipment and general technical entry-level visual 3D modeling software Autodesk-123DCatch and 3DSmax for the experimental operation, to design a set of experiments which could be used for 3D digital skull universal teaching. It has achieved good results.

KEY WORDS 3D digital skull reconstruction, experiment teaching, forensic science

1. INTRODUCTION

Skull resemblance or skull resuscitation technique refers to the use of various kinds of sculpture or other methods to reconstruct the craniofacial image of the skull according to the relationship between the facial features of the human head and the facial soft tissue and facial features [1]. This technology has developed from the early restoration of the traditional three-dimensional clay to the side or plane of the two-dimensional computer recovery, and then developed into the visualization in recent years, interactive operation of three-dimensional digital skull recovery, and constantly adapts to the needs of criminal investigation technology development and information age requirements. However, in the practice of higher education, due to public security criminal investigators have three-dimensional digital skull complex imaging technology, is built on a large data system and internal technical software on the basis of the operation, for those who have not received the relevant professional and technical training Ordinary law students are almost hard to reach. So few teachers in the teaching of material science and technology design and carry out the relevant skull complex imaging project.

The so-called three-dimensional digital skull image, the first is the use of model data digital scanning technology to scan the skull model. On the basis of the acquired scanning data, the skull model is digitized and modeled and edited. Based on the sculpture technique used in the restoration of traditional clay, the characteristics of the facial features of the skull are deduced [2] by means of the interactive three-dimensional modeling design software through forensic identification, anthropological observation and statistical data analysis. The data of skin and soft tissue thickness of the characteristic points obtained by medical image observation are used to restore the skull. In criminal detection, for the lack of witnesses and other reasons cannot carry out criminal investigation of the portrait or homicide site can only find broken craniotomy and other difficult cases, three-dimensional digital complex image relative to the traditional clay skull complex image or criminal investigation portrait has more High accuracy and degree of identification.

In order to be able to popularize the relevant knowledge of common law students, to enrich the evidence science and technology experimental teaching means, our team used the general teaching laboratory equipment owned by ordinary university laboratory combined with the relevant three-dimensional image editing software to design a set of Three - Dimensional Digital Skull Imaging Experiment of Universal Teaching. Although the experiment cannot meet the requirements of the criminal investigation in the recovery of the technical standards, it can be more rapid, objective and image of the digital skull complex imaging technology theory and technical processes, and for the

teaching of teaching in the skull it has a certain reference value.

2. THE EXPERIMENTAL PRINCIPLE

In this experimental design, the team was divided into three stages of the entire experimental process, namely skull three-dimensional scanning modeling, skull digital three-dimensional model processing and editing, digital model of the physical display, as shown in Figure 1.

2.1. Principle of 3D scanning modeling technology

Three-dimensional scanning modeling technology is set of light, machine, electricity and computer technology in one of the high-tech, mainly for the object space shape and structure and color scanning, in order to obtain the object surface space coordinate information [3]. It can more quickly and easily the skull of the three-dimensional information into a computer directly to deal with digital information.

At the present stage, the three-dimensional scanning mode can be divided into two categories: non-contact and contact. The non-contact 3D data acquisition uses depth image technology and sensor technology, combined with the nonlinear solution and other normalization methods; The main non-contact 3D acquisition methods are structured light method, three-dimensional reconstruction of the CT method and nuclear magnetic resonance method, stereo parallax method, pulse ranging method, *etc*. Contact measurement, also known as mechanical measurement, is a traditional measurement method: The measurement space of the object is placed in the three coordinate measuring machine, using the measuring head connected to the measuring device on (or probes) in direct contact with the measured point, according to the geometric structure of the measuring device coordinate measuring head, and the space coordinates of these points, obtained through calculation of the measured object geometry and the shape and position. The typical contact three-dimensional scanning device includes Coordinate Measuring Machine (CMM) and the follow-up three-dimensional scanner [4].

Because of the expensive equipment and the difficulty of technology, it is difficult to apply this method to the experimental teaching of the course of science and technology of physical evidence. Therefore, we decided to use a simpler, low-cost, convenient camera scanning for skull structure data collection.

Camera type spatial scanning, namely the use of camera 3D scanner to scan the space mapping object, combined with three-dimensional modeling software suitable for ordinary users to generate three-dimensional model, scanning obtained 3D modeling effect.

2.2. 3D model editing technology

Three dimensional model editing and processing technology, refers to the use of three-dimensional modeling rendering software for three-dimensional scanning of the modeling information to be edited and processed computer technology. Through early DOS system software based on 3D studio series, with the development of the visual interface of the operating system, now appeared on the market a series such as SOLIDWORK, 3DsMAX, blender, Meshmixer, Rhinoceros, Magics, Zbrush and other interactive 3D visualization and processing software, greatly reduces the difficulty of 3D data processing. In addition, some software can also be used for the production of virtual animation, easy to grasp, suitable for experimental teaching activities.

In this paper, the 3D model processing technique is used to simulate the process of restoring the skull image by using the traditional clay restoration method. Compared with the physical restoration method, the 3D image processing software is used to restore the process, which is more clean and efficient. In judicial practice, it is also used to realize the reduction of the skull image.

2.3. 3D printing technology

Three dimensional printing technology, also known as three-dimensional printing technology, is a kind of rapid prototyping technology (RP). It is a kind of technology based on the digital model file, which can be used to construct the object by the method of layer by layer printing. In the past, it is often used in the field of mold manufacturing, industrial design and other fields [5]. Compared to the flat printing, 3D printing technology is young, but because of the networking technology continue to improve and promote, three-dimensional printing technology will have more application in the field of the future industrial and medical, and experiment.

There are many types of stereo printers. Among them, the metal wire, plastic wire after the formation of a layer of LOM. The utility model has the advantages of low cost, small size, and can be used for the display of the desktop experiment. The experiment team uses the assembly type of LOM printer, Qingxin 3D printer, belonging to the lightweight, low temperature 3D printer. The molten material is PLA plastic. It is used in the final process of skull image reconstruction, that is, the physical output of the skull.

The use of three-dimensional printing technology can reconstruct the 3D digital model in a short time. In skull reconstruction, it can be achieved as the original appearance of the reconstructed skull. The objective of the traditional skull restoration is to obtain the image of the deceased's face, and if combined with three-dimensional printing technology, it will be able to draw a more specific three-dimensional model than the plane image. Because of the application of three-dimensional printing technology in physical evidence technology is still in the initial stage, so the degree of recognition of the skull reduction is relatively low. If we can adopt more industrial grade fine three-dimensional printer, it may be able to output the ideal stereo

model of the original appearance of the skull.

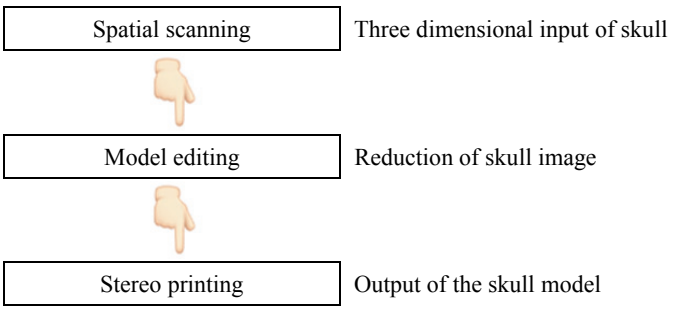


Fig.1

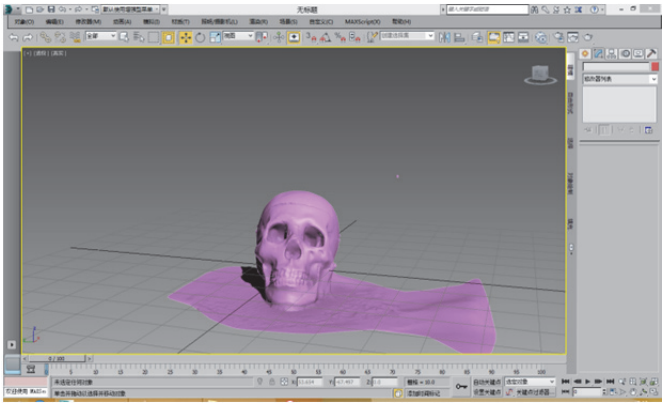


Fig.2 Digital image model of skull

3. EXPERIMENTAL STEPS

3.1. Acquisition and modeling of 3D image data of skull

In this experiment, the 3D image data acquisition and modeling software of the skull is Autodesk123DCatch, and the spatial scanning is carried out by using the plane image.

In the stage of spatial scanning, the team used the Nikon 600D camera, by controlling the shooting angle, multi angle on the skull of the shooting, made a photo about 70 skull prototype, submitted to the Autodesk123DCatch server, to make a three-dimensional model of the skull head.

In the process of simulation experiment teaching, the experiment is easy to grasp, so it is easy for students to master. We can get a more accurate three-dimensional model of the skull by using a digital camera with a DSLR camera. The experimental variable to be controlled is the number of flat photographs. Due to the principle of the Autodesk123DCatch server to simulate the reduction of the scene around the camera, so the degree of detail of the model and the number of photos uploaded by the client has considerable contact. And in the process of taking pictures, try to keep the camera shooting plane and the skull and the angle between the prototype and the same height, otherwise easily lead to dislocation of the model.

In the modeling phase, we mainly solve the problem of the unification of the 3D image file format. Autodesk123DCatch can output obj, stl, dwg, *etc.*, can be used for CAD, 3Dmax and other image processing software editing file format. The obj format images, containing material copy, have a high degree of reduction, so the 3D image modeling of skull Autodesk123DCatch instructions should export obj file format, to prepare for the appearance of reduction (Figure 2).

3.2. Reduction and editing of facial 3D digital model

The 3D digital model of facial reduction editing, is the use of computer in interactive 3D image processing software, simulate the traditional clay restoration method like the original process of cranial reduction. The restoration process of the skull is divided into several parts, such as the calibration of characteristic point labels and the filling of soft tissue [6]. The simulation experiment is to gradually achieve the above process in the computer.

3.2.1. Feature point labeling

Craniofacial reconstruction needs to first obtain the 3D digital skull, and then add the data to the 3D digital soft tissue on the skull, thus completing the skull reconstruction process. From this description is visible, the prerequisite of craniofacial reconstruction completion is to obtain the soft tissue thickness data. The calibration of feature point labels is the process of locating and limiting the feature points on the skull and preparing for the soft tissue filling in the future according to the statistical data.Based on the literature of the experimental team [7], the scientific community is usually used in soft tissues of the head feature of skull complex like 36 points, as shown in Figure 3 [8].

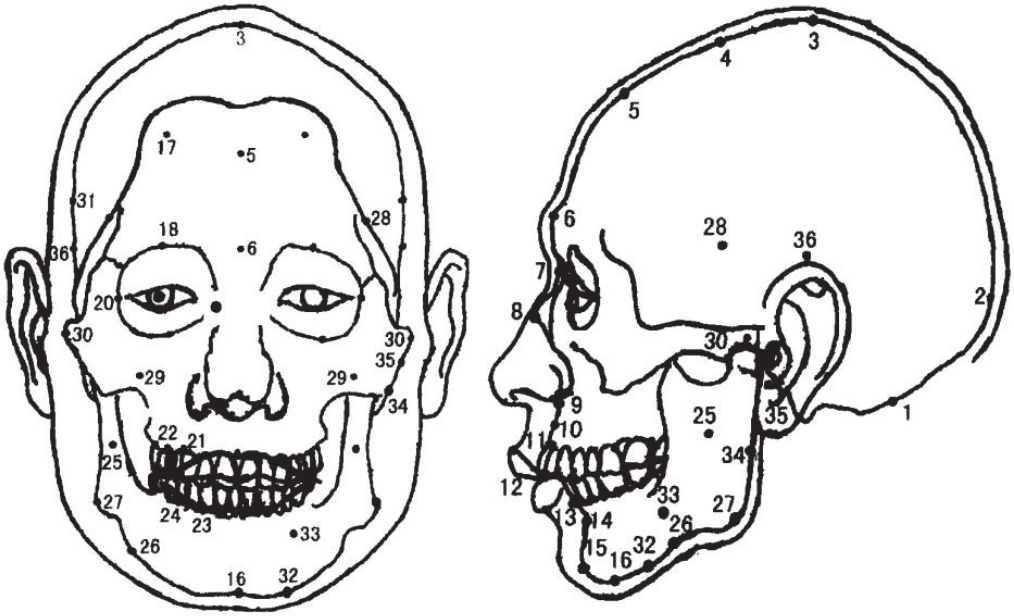
There is a large amount of statistical data on the average thickness of soft tissue thickness of soft tissue thickness of the above characteristics. In this experiment, the average value was used as the calibration data.

The label calibration work of soft tissue characteristics, its operation is not too difficult. Using the powerful modeling function of 3Dmax, the model of label is established, and the label is calibrated by moving and editing to the skull image. In the process of teaching experiment, the students need to calculate the proportion of the three-dimensional model of the skull, so as to adjust the length of the cylinder model. The above functions can be quickly realized in the integrated 3D image processing software 3Dmax.

3.2.2. Reduction of soft tissue

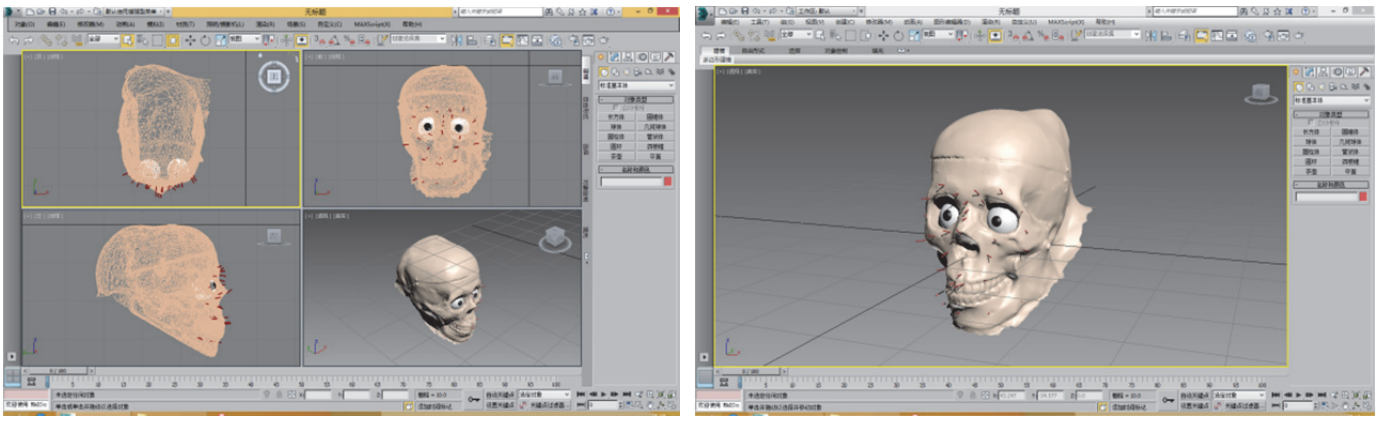
On the basis of the first part of the calibration of soft tissue characteristics, it is to fill the soft tissue according to the statistical data of soft tissue thickness. The simulation of the simulation experiment can be used in the clay restoration method, which takes a long time to fill the clay. The use of 3Dmax muscle tissue model, including the modeling method of veneer sheet and the modeling method of NUBRS correction based on sphere model. In the

teaching process of the simulation experiment, the two methods can be mastered and used by the students. Surface veneer modeling method draw contour muscle and soft tissue in the craniofacial structure, and then use the extrusion tool, adjust the thickness of the soft tissue, realize the reduction of soft tissue. The proposed method can obtain more realistic soft tissue images, but the students need to fine tune the operation of spline modeling, and draw the accurate soft tissue profile. But the sphere model NUBRS correction modeling, refers to the establishment of the radius of sphere model and soft tissue thickness statistically equal, then can be directly converted to NUBRS surface model by using the 3Dmax sphere model, through the side pattern adjustment, realize the preliminary reduction of soft tissue three-dimensional model, fit to the calibration to be filled the connection between feature points can be. The method requires students to master NUBRS method to modify the surface model, and may be encountered in the teaching experiment is difficult to calculate and control the displacement of the size of the surface model, need to use skillfully after repeated experimental operation.



1 枕外隆凸点　2 后头点　3 头顶点　4 颞额颧点　5 额中点　6 眉间点　7 鼻根点　8 鼻骨末端点　9 鼻棘点
10 鼻棘下点　11 上齿槽前点　12 口裂厚　13 下齿槽前点　14 颏唇沟点　15 颌前点　16 颌下点　17 冠颞点
18 眶额颧点(眶上缘)　19 眶下点(眶下缘)　20 眶外缘点　21 上颌 3～4间牙槽点　22 上颌 5～6间牙槽点
23 下颌 3～4间牙槽点　24 下颌 5～6间牙槽点　25 下颌枝中点　26 下颌体外缘咬肌前　27 下颌角点
28 额颞点　29 颧骨点　30 颧弓点　31 侧头点　32 颏前外侧点　33 颏孔点　34 耳垂前点
35 耳屏点　36 颞骨点(平耳廓)

Fig.3



a　　b

Fig.4

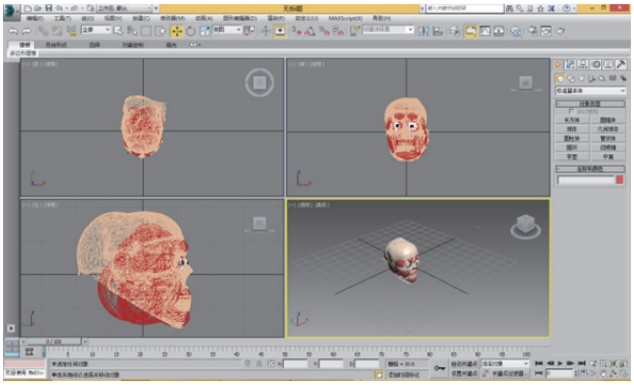


Fig.5

3.2.3. Registration and shaping of facial features

In 3DMAX, both the front and side views of a realistic model can be made in the work window, making it easier for facial features of the skull. In the frontal view, according to the characteristics of the eyes, mouth and nose point near the target roughly two angles, draw eyes nose lips width, thickness and width; determine a good lip height, nasal height in the nose side view. Through the details of the modification, you can restore the face of the skull.

a

b

Fig.6

3.3. Three dimensional 3D model solid output after facial reconstruction

Using the three-dimensional printing technology, we can make the restored cranial model of second links to be materialized. The team selected Qingxin M6 3D printer consumables with white PLA. Firstly, the printing speed and precision are set up on the random software, and the temperature of the nozzle and the hot bed is adjusted, and then the skull model is loaded into the printing interface, and the slice software is used for slicing and generating the print script. In this software, the accuracy of each layer can be set, and the thickness of the first layer can be adjusted. The first level of printing is critical, and its success will determine the success or failure of the entire model printing. In the slice software, the thickness of the first layer is controlled by setting the nearest distance between the nozzle and the hot bed. If too loose, too thick, easy to move, printing failure rate is high; if too tight, the nozzle and the hot bed contact pressure is too large to move. This requires repeated adjustments in the software between the nozzle and the distance between the hot bed.，With a page A4 paper to test, it is most appropriate to be able to move around before and after.

4. RESULTS AND DISCUSSION

Our project team uses the desktop level of the three-dimensional printer to simulate the original image after the reduction of the shadow output, and then summed up the impact of three-dimensional printing parameters are the main problem, the hot bed temperature, extrusion head speed and so on several aspects. Different parameters will lead to differences in printing results, such as the temperature is too low, resulting in ABS plastic wire cannot be completely melted, affecting the laying of the layers, and moving too fast will lead to the output part of the model is missing. Therefore, in the simulation experiment teaching, the operator needs to control the parameters of the method, so that students master the best combination of working parameters, which output a more ideal skull physical model.

5. CONCLUSION

In the computer to achieve skull complex image is a computer research field is more cutting-edge issues. Physical evidence technology is often the re-use of the field of computer research.

The real use of criminal investigation practice digital skull complex image technology, due to a higher degree of distinction and fine requirements, often require professional and technical personnel through the accumulation of long experience to master. But through the design of simulation experiments to simulate digital skull imaging technology, in the evidence science and technology teaching experiments, can be relatively comprehensive and image of the skull complex imaging technology. Because it belongs to the simulation experiment, the recognition degree of the original image of the skull does not need to meet the requirement of criminal investigation. Only the process and principle of the digital skull complex image can be used to achieve the purpose of experimental teaching. Therefore, this paper briefly introduces the digital skull complex image by the use of technology in information technology, and usually can be mastered by the general laboratory of simple and fast technology from a variety of techniques, that a simple simulation of complex process technology like digital skull technology, preliminary experimental results can be obtained.

ACKNOWLEDGEMENTS

This project was supported partially by Chongqing Science and Technology Innovation Project of Social Undertakings and Livelihood Security (cstc2015shmszx00004), China.

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