3D face modeling and rapid casting based on reverse design

Huihui Liu1,a, Shengping Ye1, Ming kong1, Yueting Zhu1, Ya Jin1, Weihong Yang1
1Wenhua college, Wuhan, Hubei, 430074, China
a-e-mail: 270850618@qq.com

Abstract. This paper first obtains human body data based on a 3D scanner, combines with Geomagic Studio to obtain a 3D model; and explores three 3D printing technologies for rapid prototyping of the model. The 3D prototype is turned out of the wax mold using the silicone rubber reworking process, and finally the melting is used. Mold casting process to complete portrait casting. Practice has proved that this method realizes the entire workflow of 3D face data acquisition, rapid prototyping, and rapid casting, and has high application value and market prospects in the production of 3D portrait artwork.

1. Introduction
Automatic acquisition of 3D portrait data and high-precision reconstruction are the research hotspots of 3D face recognition. It has high application prospects in the fields of information confidentiality, security authentication, criminal investigation systems, etc. The modeling of complex curved surfaces like the human body requires reverse engineering technology [1]. This article introduces the process of combining reverse engineering technology and 3D printing technology with investment casting technology through a case of human body surface modeling (the process is shown in Figure 1). In this process, the 3D printed prototype is turned out of the wax model by the silicon rubber reworking process, and then the model shell is made, and then the high temperature dewaxing and baking are performed, and then the casting is poured into shape. This technology can effectively shorten the cycle and reduce the production cost in the production of three-dimensional portrait art, and has high application value and market prospects.

![Figure 1. Process of making bronze statue](image)

2. 3D face reverse modeling process
In this paper, a handheld 3D scanner is used for human body data collection, mainly collecting the upper body area of the human body, using the machine to rotate around the person 3600 to collect the human body surface data, and then using Geomagic software to post-process the measured point cloud data to obtain a 3D model. The processing process is as follows:

1) Preprocessing of point cloud data. Since the human body scan is completed at one time in 360 degrees, the data is a complete single piece of data, which avoids the process of merging after ordinary multiple scans. However, due to the slight movement of the human body during the collection process and the irregular movement of the equipment, some noise points are also collected. Therefore, the
"reduce noise" and "in vitro solitary points" commands in Geomagic are used for processing. The quality of the point cloud processing is directly related to whether the subsequent polygon objects can be obtained faster and better, so the point cloud preprocessing is very important.

2) One-sided processing of polygons. The processed point cloud is converted into a triangular patch through the "encapsulate" command. Since the packaged model has some defects and errors such as holes, redundant triangles, or surface irregularities, it must be repaired.

3) Surface reconstruction. In the Geomagic software, select the shape module to enter. The contour processing mainly includes detecting contour lines and detecting curvature, editing, lifting constraints, etc. For models with inconspicuous human contour shapes and complex and irregular shapes, the curvature detection method is preferred. You can create a surface patch layout by hand. Then execute "construct grid" and adjust the grid position, and finally execute the "fit surface" command to create a human body NURBS surface.

![Figure 2. 3D scan data of Professor Ye](image1)

![Figure 3. Three-dimensional scan data of Professor Huang and his wife](image2)

3. Bronze casting based on 3D rapid prototyping technology

As a rapid prototyping technology, 3D printing technology has a strong compatibility with casting and can be well applied to traditional casting production. Among them, investment casting and 3D printing technology are well combined [2]. 3D printed parts can be directly used as wax molds for investment casting, but in this article, the silicon rubber reworking process is used to turn the 3D printed parts prototype out of the wax mold. Investment casting technology has the advantages of stable process and flexible production organization. 3D printing prototypes are directly used in investment casting technology for rapid trial production and small batch customized production. This technology has obvious technical and economic advantages [3].

3.1 Bronze statue casting based on SLA 3D printing

The forming principle of the stereo light curing technology (SLA) is using a laser of a specific wavelength and intensity to focus on the surface of the light curing material, so that the liquid photosensitive resin undergoes photopolymerization to form a solid part section layer by layer, and then the lifting platform moves one in the vertical direction. The height of the layer, then another layer is cured. Such layers are superimposed to form a three-dimensional entity.

The brief process of portrait casting based on SLA in this article is as follows: First, save the reverse-processed CAD data model as an STL data format that can be recognized by a 3D printer, and then use the light curing molding equipment to print and print to obtain a portrait prototype, as shown in Figure 4. It shows that the portrait prototype manufactured by SLA has high dimensional accuracy and good surface quality. Based on this prototype, a wax mold was made using the silicone rubber reversal process (see Figure 5). Finally, the bronze statue was cast according to the wax model (Figure 6).
3.2 Bronze statue casting based on colour printing of FDM

The forming principle of Fused Deposition Modeling (FDM): The filamentous hot-melt material is heated and melted and extruded through a nozzle with a fine nozzle. The hot melt material is melted and sprayed out from the nozzle, and deposited on the panel or the previous layer of solidified material. When the temperature is lower than the solidification temperature, it begins to solidify, and the final product is formed through the accumulation of layers of materials. In 3D printing technology, FDM has the simplest mechanical structure, the easiest design, and the lowest manufacturing cost, maintenance cost, and material cost.

The process of FDM-based rapid casting of portraits is similar to the above. first save the reverse-processed CAD data model as an STL data format that can be recognized by a 3D printer, and then use FDM printing to print to obtain the FDM portrait prototype. The FDM prototype was used for investment casting and the bronze statue was finally made.

In most FDM 3D printers, the colour of the print can only be consistent with the colour of the consumable filament used, which results in a single colour of the print and cannot print products with rich colours. With the development of 3D printing technology, some two-colour or multi-colour 3D printers have been produced that do not need to switch nozzles. This article uses imported 3D colour printers to print prototypes. The printed model is shown in Figure 3 with high restoration and clear outlines. However, compared with other technologies, prototypes manufactured by FDM equipment have lower dimensional accuracy and poor surface quality.
3.3 Bronze statue casting based on gypsum plastic of 3DP printing

The forming principle of three-dimensional printing technology (3DP): First, the powder spreading mechanism accurately spreads a thin layer of powder material on the processing platform, and then the inkjet print head sprays a special layer on the powder according to the cross-sectional shape of this layer. Glue, a thin layer of powder sprayed onto the glue solidifies. Then spread a layer of powder with a certain thickness on this layer, and the print head sprays glue on the shape of a cross section. So layer by layer, from bottom to top, until all layers of a part are printed. Then the uncured powder is cleaned out to get a three-dimensional physical prototype.

The brief process of 3DP-based rapid casting of portraits is similar to the above: First, the three-dimensional portrait model obtained by the reverse processing is directly bonded and formed by the 3DP equipment to obtain the portrait prototype, and the portrait prototype is used for investment casting, and finally copper is produced.

This article uses a low-cost 3D printing material, plastic gypsum, launched by Wuhan Yuguang Technology Co., Ltd. for printing. A 3D printed prototype with a height of about 250 mm was printed (see Figure 4). The surface quality of the prototype is better than FDM, there is no trace of fuse wire, and it is directly used for casting to obtain a bronze image.

4. Conclusions

(1) The use of 3D scanning and Geomagic software can quickly and efficiently process the design of complex surface models similar to human faces.

(2) Compared with the three rapid prototyping technologies, the SLA printing technology obtains prototypes with high dimensional accuracy and good surface quality, but the price is relatively expensive.

(3) The combination of 3D printing technology and investment precision casting technology to cast portraits not only has the advantages of 3D printing technology, such as short manufacturing cycle and low production cost, but also has the characteristics of high investment casting dimensional accuracy and good surface quality. Private customization has broad application prospects.
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