Research on Application of Reverse Engineering and 3D Printing Technology in Object Recognition

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Abstract. Through the combination of reverse engineering and 3D printing technology, existing products can be upgraded or partially adjusted, which is an important method in product manufacturing. In this paper, aiming at the problems such as the easy damage of objects such as milk tea cups when accidentally falling or being hit and the recently released environmental protection plastic limit, Einscan Pro handheld 3D scanner is used to collect the surface data of milk tea cups, and the data processing, model reconstruction and precision analysis are carried out in the Geomagic series software. Then Ansys Spaceclaim software is used to model the cup sheath, and finally through FDM molding method, the use of degradable PLA materials integrated processing molding, so that its appearance is beautiful, can perfectly fit with the cup body and has a high degree of stability in the process of carrying, and is conducive to environmental protection.

1. Introduction

Reverse engineering (RE), also known as reverse technology. It is a kind of advanced manufacturing technology which takes the physical product as the research object, obtains its surface topography information by using three-dimensional scanner [1], preprocesses it and then constructs the solid model by reverse modeling, and takes this model as the framework to innovate the design of the product, and finally generates the physical model. The use of reverse engineering technology can make the product development more purposeful, and finally achieve the purpose of saving time, saving cost and improving efficiency [2-4]. Additive manufacturing (AM) is also called 3D printing technology. The fusion deposition modeling (FDM) technology included in it has been quite popular at home and abroad [5-6]. FDM technology is one of the fastest developing and most widely used 3D printing technologies. It is simple to operate, small molding equipment, easy to place, and can be used in the office and other environments [7].

The combination of reverse engineering and 3D printing technology with product innovation design is a very important development direction in the field of intelligent manufacturing in the future [1]. It is particularly important to effectively combine the two technologies and apply them to the development of new products [8-9]. For the application of the combination of reverse engineering and 3D printing technology, domestic and foreign scholars have done a lot of research. For example, Wang et al. [10] based on reverse engineering, product innovation design and 3D printing technology, constructed the technical route of helmet product rapid design and development, optimized the product production process, shortened the product development cycle and improved the production efficiency. Baronio et
al. [11] combined 3D printing and 3D scanning technology to realize the custom production of hand orthotics. By using reverse engineering to obtain forearm data, and using 3D printing technology to output the hand orthotics model, they realized the lightweight design of the product, reduced the production cost, while still ensuring the accuracy of data. Through reverse engineering technology, combined with model optimization design, finite element analysis and 3D printing technology, Zhang et al. [12] quickly and accurately obtained the 3D digital model of the product and output the product model, thus improving the development efficiency of new products. Lei et al. [13] carried out research on product redesign, which combined reverse engineering and rapid prototyping technology, and effectively verified the practicability and superiority of product redesign. Tian et al. [14] used reverse engineering and prototyping techniques in order to quickly match the femoral prosthesis with the human body, so as to skillfully shorten the production cycle and reduce the cost of patients. Zhong et al. [15] studied the innovative design of traditional furniture in the new era based on the combination of reverse engineering and rapid prototyping technology. The above literature analysis shows that reverse engineering and 3D printing technology have important application prospects in new product development [16].

2. Research Process and Method

2.1. Data acquisition and processing
This paper chooses a certain surface characteristics of common plastic milk tea cup as a typical research object, because the milk tea cup surface phenomenon of translucent, so choose new of DPT-5 imaging agent powder processing, and use in the first 3D technology co., LTD production of Einscan Pro handheld 3D topography data 3D scanner to get milk tea cup, tea cup and scanner is shown in Figure 1.

![Figure 1. Milk tea cup and scanner](image)

This measurement method does not need to touch the measured object and will not cause damage to the surface of the object. Therefore, it can also be used to measure some flexible objects and some inconvenient objects, such as precious cultural relics, etc., and it is faster than the contact measurement and collection speed. The main parameters of the scanner are shown in Table 1.

| Scanner Model | Scanning speed /point/s | Highest accuracy /mm | Minimum size /mm*mm*mm | Single chip scanning range /mm*mm | Light source |
|---------------|-------------------------|----------------------|-------------------------|---------------------------------|-------------|
| Einscan pro   | 450000                  | 0.05                 | 30*30*30                | 210*150                         | LED         |

Scanning completed select encapsulation and save to STL format. At this time, the number of triangular surfaces is 74585, and the amount of data is relatively large. Moreover, there are different degrees of noise points, isolated points outside the body and broken surfaces on the surface, so it is necessary to import the Geomagic Studio software to convert the model into point cloud data and carry
out preprocessing operations. After the import, the units are set to millimeters, and the mesh doctor command is used to analyze and repair the polygon mesh. By adjusting the sampling rate to streamline of point cloud data, reduced the number of triangles in 20801, and then use populate a single hole command, in turn, points of existing hole repair, remove nail synthesis command to detect and flattening single point on the polygon mesh spike, relaxation and smooth the rapid command make the polygon mesh smooth, the effect as shown in Figure 2.

![Figure 2. Comparison before and after pretreatment](image)

Finally will be repaired by detecting point cloud data to construct surface curvature and NURBS surface fitting method to obtain ideal surface, and then carry on the deviation analysis to determine whether can be used to reverse modeling, as shown in Figure 3, the maximum deviation is +0.3041 mm, the minimum deviation is 0.2103 mm, the standard deviation is 0.0200 mm, comply with the design requirements, for the next step of reverse modeling operations, and save it to the STL format.

![Figure 3. Surface accuracy deviation](image)

2.2. Reverse modeling

Import the triangular section data model into Geomagic DesignX software, and segment the field of the model data so as to fit and cut the section easily. Comprehensive consideration of various factors such as surface continuity and surface accuracy, should be on the premise of guarantee the surface modeling accuracy to minimize the number of areas, to define domain group of curved surface fitting and joining together later, after the rest was carried out on the different positions of the body of another fitting, surface between cross, therefore it is necessary to shear the surface operation, before and after the shear effect is shown in Figure 4.
After the main features of the product are designed by reverse modeling, the detailed design of the product can be improved by using such commands as chamfering and shell pulling, etc., and the complete model can be finally modeled by continuously optimizing and revising the accuracy detection graph, as shown in Figure 5. And save it as STL format file for subsequent innovative design of cup model.

2.3. Forward modeling and design

The model was imported into the software Ansys Spaceclaim, and according to the cross-section model of the milk tea cup, a two-dimensional model with the appropriate size of the cup sleeve side was drawn in the plane. The width of the gap between the inner wall of the cup sleeve and the plastic cup was set as 1mm, so as to achieve a good matching effect without squeezing the cup body and improve the stability. Then, the appearance of the cup sleeve is designed from the perspectives of aesthetics, practicality and lightness. A structure suitable for holding is added to the cup sleeve according to the ergonomic design principle, and a lightness design concept is added in combination with dot matrix structure to reduce the weight of the cup sleeve. The effect is shown in Figure 6.
In addition, in order to improve the stability in the process of milk tea cup with performance, this paper combined with the design concept of gyroscope, put forward a kind of two degree of freedom structure stability, the structure is mainly composed of a large and a small two ring and a handle, because use FDM3D printing technology generates the one-piece structure, so the connector design for embedded cooperate, make its have the better than the traditional separation manufacturing cooperation effect, as shown in Figure 7.

![Figure 7. Two degrees of freedom stable structure](image)

2.4. Model making

Import the designed model into the slicing software Cura17.08.16. The printing parameters adopted are shown in Table 2, and the default values for other parameters are adopted.

| Thick /mm | Wall thickness /mm | Fill rates /% | Printing speed /mm/s | Nozzle temperature /°C | Printing platform temperature /°C |
|-----------|-------------------|--------------|----------------------|------------------------|-------------------------------|
| 0.05      | 0.8               | 100          | 80                   | 210                    | 70                            |

After slitting, the model is saved in GCode format and printed by FDM3D printer. The printer model is MakerPim2 series printer, and its product type is desktop printer. The size of the printing platform is 200*200*300mm, the positioning accuracy of XY axis is 0.0128mm, and the positioning accuracy of Z axis is 0.0025mm, which meets the requirements. Degradable PLA materials are used for integrated molding, as shown in Figure 8.

![Figure 8. Add material manufacture](image)

3. Discussion and Conclusion

Traditional plastic straws will be banned from drinks such as milk tea and replaced with paper straws as of Jan 1, 2021, in a further escalation of the plastic limit [17]. However, paper straws are often easy to become soft or even fall apart, and the function of holes is relatively weak [18-19]. At the same time, some paper straws still retain the smell of paper, which greatly reduces the taste of milk tea. In addition,
milk tea cups are vulnerable to collision and shaking when carrying milk tea or when the delivery worker is delivering food [20]. In view of the above problems, this paper verified the feasibility of applying reverse engineering and 3D printing technology in the model innovation design and manufacturing. Compared with the traditional forward modeling design, the cup sleeve designed in this way has better fit and aesthetic properties, and the design process is more flexible. A stable structure with two degrees of freedom based on the design concept of gyroscope is proposed, which greatly improves the stability. And the use of FDM 3D printer for one-piece printing and molding can achieve the embedded fit that is difficult to achieve in the traditional split manufacturing. It has better fit effect, is not easy to fall off, and has high reliability. The use of PLA materials to replace the original plastic and paper materials can not only be conducive to environmental protection, but also maintain the original taste of milk tea, can improve the sense of identity of consumers, and fit the concept of sustainable development, with a good development prospect.

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