Application of reverse engineering in the medical industry.

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Abstract. The purpose of this research is to develop on the basis of existing analogs new design of ophthalmologic microsurgical tweezers by using reverse engineering techniques. Virtual model was obtained by using a three-dimensional scanning system Solutionix Rexc an 450 MP. Geomagic Studio program was used to remove defects and inaccuracies of the obtained parametric model. A prototype of the finished model was made on the installation of laser stereolithography Projet 6000. Total time of the creation was 16 hours from the reverse engineering procedure to 3D-printing of the prototype.

Introduction

Reverse engineering is the method obtaining three-dimensional data in computerized form from physical models or products. It has clear benefits of effective use together with additive technologies and vacuum casting in silicone molds. [1]

3D printing, also known as additive manufacturing technology, creates the object layer by layer. 3D printers can produce more complicated shapes than traditional manufacturing techniques. Currently, 3D printing involves areas: manufacture of individual surgical templates, fabrication of individual surgical implants and prostheses, spinal implants manufacturing, manufacturing a variety of orthopedic and prosthetic constructions in dentistry. [2]

Complex geometric form of the medical instrument complicates the process of measuring of the control size and determine of the exact geometry. Tweezers used in microsurgery of the eye are subject to frequent changes in design appearance. On the one hand, the simplicity of the tool, on the other hand the complexity of the geometry of the handle of sticking has necessitated the use of reverse engineering. Therefore, the aim of this work was to explore the possibility of reverse engineering, in this example the speed of obtaining the product prototype.

Main part
For the analysis of tweezers scanning features three 3D-scanner were selected: Solutionix Rexcan 450 MP, Smart Optics Activity 850, Artec Spider.

Artec Spider is the professional manual 3D scanner. The device uses an LED backlight in combination with four cameras 1,3Mp resolution. Scan rate up to 7.5 frames (or 1,000,000 measurements) per second. The accuracy of scanning 0,05 mm.

Smart Optics Activity 875 is a desktop optical 3D-scanner with enhanced performance. The device is designed to produce high-precision digital models. The scanner has a high resolution, which reaches 0.01 mm. The scanning process is fully automated and takes about one or three minutes, depending on the size of the object. The obtained data are exported as STL file.

Solutionix Rexcan 450 MP is a professional 3D-scanner that creates highly accurate three-dimensional models of real objects with a resolution of 5 megapixels. The device works on the contactless method of the optical phase triangulation of a structured white light. Variable angle of triangulation and adjustable scanning area provide an opportunity to obtain scans accuracy of 0.01 mm.

Artec Spider was chosen first for scanning. It has the lowest resolution camera consequently the accuracy of the scan he also low. It is portable and does not require calibration. The scanning process showed that for small objects such as tweezers, it is not suitable. It was decided to abandon this type of scanner because the scan has a lot of noise and inaccuracies.

Smart Optics Activity 875 has a high accuracy of scanning, does not need in the calibration, and the scanning process is automated. This scanner is designed to scan objects with a diameter up to 85 mm and tweezers exceeds this size.

Solutionix Rexcan MP 450 has the same accuracy of the scanning that Activity 875 but it needs to be calibrated. Calibration performed to determine the relative position and provide high accuracy of measurements. It is necessary to guideways the intersection point should be at the center of the middle group of the target on the calibration panel (Fig.1). After calibration, the scanning process begins. It became possible to scan deep and narrow zones of complex shapes through the use of triangulation angle equal to 10°. Dead zones, which were difficult to scan with a standard angle, can now be covered by means of the triangulation angle equal to 10 °. The scanner shines with structured light on the product and receives information about the distance to the object surfaces by reflection from the surface. Sectors of surface model are created using this information. After a sufficient number of such sectors, the specialized software ezScan connects them into a single object in the automatic or manual mode. The format of the exported model is SNX and its quality is not suitable for 3D printing. Scan of model need to be translated into STL format and processed in the program Geomagic Studio.
Fig.1. Calibration of scanner.

Even with a perfect surface of scanning (volumetric, white, matt, without tight spaces and sharp edges) 3D scanner captures still various noises. These can be characteristics of the object and the external conditions and the characteristics of the scanner. Eventually unnecessary roughness, tunnels and holes and other artifacts are formed. The resulting surface of the object can be viewed in different ways: as a cloud of points or mesh. In the second case, all the points are connected into triangles, which form a million microsurface. This grid is a complete polygonal model. It can be saved in stl format or other formats [4] (Fig.2).

Fig.2. Processing of tweezers in the program Geomagic Studio

At the first stage should be to "clean up" the cloud of points obtained from the scanner, remove excess geometry and reduce the spread of the points from the average value.

Tool "Mesh Doctor" removes all the defects in the automatic mode. After we connect misalignment scans and build surface on the unscanned areas. Also at this stage it is possible to change the number of polygons and their distribution, by optimizing the model what will reduce its size. The total model processing time was 12 hours.

SLA-technology has been selected for printing. This method is based on laser irradiation of the liquid photopolymer resin for creating solid physical models. Construction of the model is produced by layer upon layer. Each layer is sintered by a laser beam according
to the program. Laser irradiation leads to polymerization of the material at the points of passage of the laser beam. [3]

After printing is complete the product is washed to remove the liquid photopolymer and is processed in the ultraviolet chamber. Stereolithography requires the use of support structures for the construction of high-angle components of the model. Supports are generated in the "Magics" program, and are made of the same photopolymer material. Support elements are temporary construction elements which are removed manually after the completion of the manufacturing process. Existing technology allows applying fibers with a thickness of 15 microns, which is several times smaller than the thickness of a human hair. The total manufacturing time of tweezers was 2 hours. (Fig. 3)

![Fig.3. Prototype of tweezers obtained at the SLA installation Projet 6000.](image)

**Conclusion**

As a result of the work ophthalmic tweezers for microsurgery was scanned. Virtual model with a new design was created. Prototype of tweezers obtained at the SLA installation Projet 6000. The use of reverse engineering and additive technology has reduced new product development of up to 16 hours, instead of 2 weeks.

**References**

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