Application of computer-aided sketching for designing the body of the non-invasive cosmetic mesotherapy device

Y S Petrov¹, V A Seryakov², Y P Khmelevsky³, E P Baklanova⁴

¹ Tomsk Polytechnic University, 30, Lenina avenue, Tomsk, 634050, Russia
² Tomsk Polytechnic University, 30, Lenina avenue, Tomsk, 634050, Russia
³ Tomsk Polytechnic University, 30, Lenina avenue, Tomsk, 634050, Russia
⁴ Xenon-jet, 30, Kirov avenue, Tomsk, 634034, Russia

Email: hmelevskiy@tpu.ru

Abstract. This paper proposes an approach to sketching the shape of a future product, based on the example of a non-invasive cosmetic mesotherapy device. To accelerate sketching of shapes in different options, the authors have developed a software program that facilitates the generation of a three-dimensional model by setting the desired parameters. The study focuses on computer-aided sketching in designing the body of the product. The subject of the study is the software program for shaping initial versions of the product. By using the developed software program, it is possible to generate initial versions of the body shape and evaluate them in terms of engineering aesthetics. The created shapes or parts of the body can be printed on a 3D printer to test the ergonomics of the shape or its parts. The innovative software program will save time on developing several options and help to make the final choice, taking into account certain criteria and manufacturing technology.

1. Introduction

Today, millions of new products are launched into the market, but not every product is a success; still fewer are user-friendly and visually aesthetic. Shaping the product is a difficult and often long process. Sketching is the first and probably the most creative stage of this process. At this stage, the designer creates many sketches to shape the product under development and defines criteria for this shape to achieve the desired result. Most often, the number and characteristics of product criteria depend on the primary function of the future product. To get the best understanding of the sketching process, let us consider this design stage using the non-invasive cosmetic mesotherapy device as an example.

2. Purpose and Components of the Device

The non-invasive cosmetic mesotherapy device is intended for cosmetic procedures in cosmetic clinics and beauty salons. The principle of operation of the device: xenon gas is supplied from a cylinder to an airbrush with a separate capsule through a hose. When you press the button on the airbrush, the serum enters the skin with a gas jet. The gas and serum ensure that cosmetics penetrate deeper into surface and middle layers of the skin.

For the purpose of this study, the body of the device is to be designed. It includes a cylinder, a pressure regulator, and an airbrush, as presented in Fig. 1. The cosmetic mesotherapy device will be installed on a table of the cosmetic room. The pressure regulator will be connected to the gas cylinder.
3. Application of Computer-Aided Sketching for Designing the Body of the Non-Invasive Mesotherapy Device

Before starting the design of the non-invasive mesotherapy device at the first stage, we should define requirements for initial sketches of the product shape:

- anthropometric and ergonomic characteristics of the adult's hand, positioning of the gas cylinder, positioning and attachment of the airbrush to the device;
- aesthetic requirements for the body shape and appearance;
- optimal, cost effective materials and manufacturing methods for the body of the device;
- the body shape that fits the purpose of the device.

After defining the requirements, we can start sketching the shape of the device body. A variety of sketch options should be created. Unfortunately, this design stage takes considerable time, and depends on designer's creative abilities and performance. It is rather difficult to immediately improve creative abilities in current conditions, but we can increase the speed of sketching by automating the process.

At present, various shaping software products, such as Rock Generator and Spline-Fibers, are available in the market.

Rock Generator is designed to procedurally generate rocks and stones for later use and visualization (Fig. 2). This software is highly specialized and intended only for generating rocks.

Features of the software:
- default settings for different shapes;
- configurable parameters;
- automatic creation of a low-poly grid with baking of coordinates;
- creation of normal and shadow maps.

Spline-Fibers can generate complex spline structures around the selected curve (Fig. 3).

Features of the software:
- configurable parameters of shapes;
- possibility to add materials and groups prior to generation directly in the software.
During the study, the authors developed a software program to automatically design and sketch initial shapes. By means of a script, various shapes based on simple geometric bodies (box, cylinder, sphere) were generated (Fig. 4). Variable input parameters include width, length and height. The functionality of the software allows the user to manipulate, generate a rounded, square or cylindrical shape, set parameters manually, or use templates.

As a result of computer-aided design, options of the body with different sizes of polygons were generated (Fig. 5). For example, the first body option with coarse triangle tessellation parameters is a polygonal style and looks like crumpled paper (Fig. 5(a)). Option No. 2 with average square-based tessellation parameters is a more elegant option with uniform distribution of faces over the entire surface of the shape (Fig. 5(b)). The third option with minimum square-based tessellation parameters is the best
one, since the shape is composed of smaller polygons, looks more aesthetically, and does not affect the integrity of the structure (Fig. 5(c)).

Figure 5. Shapes of the body created through computer aided design: (a) – coarse triangle tessellation; (b) – average square-based tessellation; (c) – minimum square-based tessellation parameter

By varying parameters to generate a variety of shapes and textures of models, and using the script, we created elegant shapes with interesting and complex textures that do not break the general shape of the product (Fig. 6)

Figure 6. Body shapes created through computer aided design

Thus, the tested version of the software program can be used for sketching shapes at the initial stage in order to determine the best visual and aesthetic characteristics. By determining script and tessellation parameters (coarse, average or minimum), it is possible to generate different options of body shapes for this and other devices and, therefore, accelerate the sketching process at initial industrial design stages.

References
[1] Seryakov V, Khmelevsky Yu and Mamontov G 2015 The design features of the body of the portable electrocardiograph «ECG-EXPRESS» *IOP Conference Series: Materials Science and Engineering* **93** 1-7
[2] Khmelevsky Yu, Seryakov V and Mamontov G 2017 Environment as a basis for the design of advertising structures by forming *Journal of Physics: Conference Series* 803 1-5

[3] Zakharova A, Vekhter E, Shklyar A, Krysko A and Saltykova O 2018 Quantitative assessment of cognitive interpretability of visualization *Scientific Visualisation* 10 145

[4] Sokolov A, Kukhta M and Solovev R 2015 Mathematical modeling in concept designing of bionic objects *International Conference on Mechanical Engineering, Automation and Control Systems (MEACS)* (Tomsk) pp 1-4

[5] Kukhta M, Sokolov A, Krauinsh D and Bouchard C 2017 Stylization levels of industrial design objects *Journal of Physics: Conference Series* 803 1-5

[6] Zakharova A, Vekhter E, Shklyar A and Pak A 2017 Visual modeling in an analysis of multidimensional data *Journal of Physics: Conference Series* 944 1-5

[7] Sun Qiang 2019 Research on the Transformation of User Perceptual Knowledge to Design Knowledge in Product Design *IOP Conf. Series: Journal of Physics* 1168 1-5