ENGINEERING SCIENCES

DEVELOPMENT OF NATURAL MODELS OF HUMAN LUNGS BY MEANS OF RAPID PROTOTYPING

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Abstract. *The initial data were spiral-computer tomographic sections of the lung area, presented in the DICOM format. It should be noted that the thickness of the transition surface formed was chosen on the assumption that the volume would be reduced by 5 times. Using the FreeCAD software, the bracket was modeling in real physical dimensions, which combined into one model with the lungs. Next, the resulting model was loaded into specialized software MeshMixer. It allows you to perform various manipulations on three-dimensional models before printing. With its use, the model was dividing in a horizontal plane into five parts. After that, each part converted to G-code using a Cura slicer, and printed with PLA plastic on a 3D printer Wanhao Duplicator i3. Then the printed parts must be join together using a guide.*
Keywords: *human lungs, medical data, segmentation, tomography, 3D printing.*

Introduction. The invention of rapid prototyping technology puts the development of medicine to a new level [1]. Creation of 3D models and printing of various organs from biocompatible materials, and in the near future from living tissues. First of all, it expands possibilities of transplantology [2, 3]. 3D modeling technologies allow research in the field of anatomical models [4, 5] and preoperative planning. [6, 7]. Therefore, when preparing specialists in biomedical engineering, it is advisable to introduce 3D printing into the educational process [8, 10]. This will show students the advanced capabilities of rapid prototyping tools and the principles of 3D printing and 3D scanning.

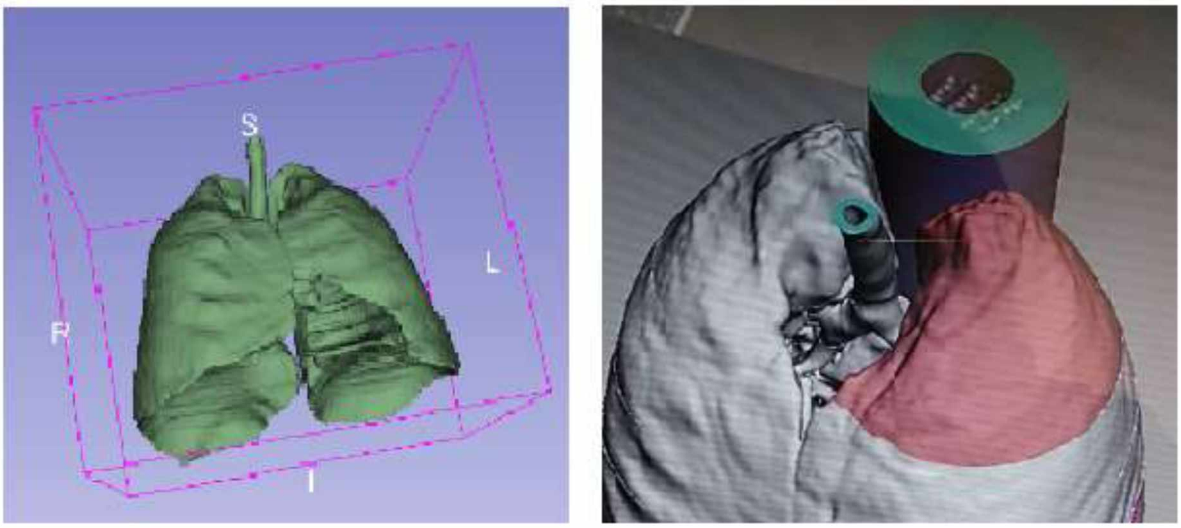
The results of the study. The aim of the work was to develop full-scale models of human lungs using rapid prototyping.

The initial data were spiral-computer tomographic sections of the lung area, presented in the DICOM format. This allows you to compare the internal organs with real physical size. Examples of coronary and frontal sections of the lungs are showing in the figure 1, a and b. Data uploaded to specialized software Slicer3D, which allows you to perform various operations on three-dimensional medical data, in particular on tomographic research. Segmentation was performing layer by layer in the region of lungs by the image segmentation module. Subsequently, only low-to-high transition areas remained, using border selection tools. It should be noted that the thickness of the transition surface formed was chosen on the assumption that the volume would be reduced by 5 times.

a b

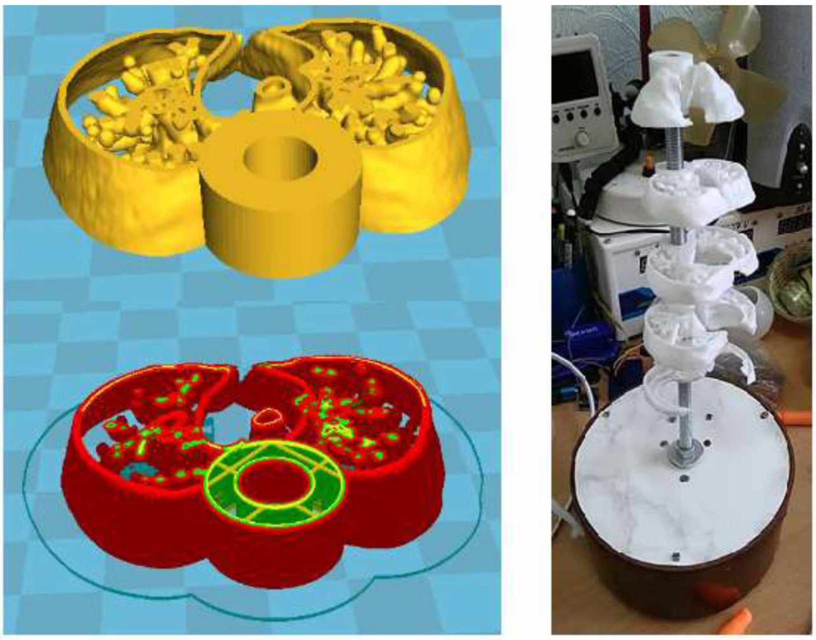
Fig. 1. Visualization of the lungs according to spiral computer tomography: a) coronary section, b) frontal section.

If the construction area is too thin, 3D printing may not be possible. Result of segmentation is a three-dimensional model of the lungs in the STL format, shown in Figure 2 a, and its segmentation was performed to eliminate visualization artifacts (Figure 2, b). Using the FreeCAD software, the bracket was modeling in real physical dimensions, which combined into one model with the lungs. Next, the resulting model was loaded into specialized software MeshMixer. It allows you to perform various manipulations on three-dimensional models before printing. With its use, the model was dividing in a horizontal plane into five parts (see Figure 3, a). After that, each part converted to G-code using a Cura slicer, and printed with PLA plastic on a 3D printer Wanhao Duplicator i3. Then the printed parts must be join together using a guide. Its rotation control microcontroller. The resulting model is presented in Figure 3, b.



a b

Fig. 2. Visualization of a 3D model of human lung: a) a geometric volumetric model, b) a segmented model of the lung region before layering for printing



a b

Fig. 3. Stages of preparation of the lung model for printing: a) layered presentation of the model; b) ready-made full-scale model of the lungs

Conclusions. Development of a model of human lung allows you to master the technology of recreating anatomical structures using personalized data of spiral computer tomography, taking into account individual variability. This can be useful in determining the volume of pathologically changed areas and planning a treatment method [10, 11]. These approaches also allow to significantly improve the technology of training specialists [12-14] of medical and bioengineering orientation.

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