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## APPLICATION OF RAPID PROTOTYPING TECHNOLOGY TO CREATION FULL-SCALE ANATOMICAL MODELS FOR EDUCATION OF HEALTHCARE PROFESSIONALS



***У статті розглянуто можливість використання технології швидкого прототипіювання для задач навчання стосовно спеціалізованих освітніх медичних закладів. Проведено тривимірну реконструкцію повітроносних шляхів носу за даними комп'ютерної томографії. На базі віртуальної моделі проведено натурну реконструкцію досліджуваної анатомічної структури. Запропоновано використовувати технології тривимірного друку для задач навчання при реалізації натурних тривимірних атласів. Це забезпечує отримання студентом не лише теоретичних навичок, а й практичних.***

***Ключові слова: навчання, натурні моделі, томографія, швидке прототипіювання***

***The article discusses the possibility of using the technology of rapid prototyping for training in specialized educational centers. We have performed three-dimensional reconstruction of the nasal cavity based on CT scans. On the basis of the virtual model we do the full-scale reconstruction of the studied anatomical structure. We propose to use three-dimensional printing technology to tasks of learning in the implementation full-scale three-dimensional atlases. It provides a student not only theoretical knowledge, but also the practical skills.***

***Keywords : learning, natural models, tomography, rapid prototyping***

With the development of mankind and with the growing number of knowledge there is a continuous transition and improvement of methods and forms of education [1-3]. One of the most important areas of scientific knowledge in social and economic terms is a healthcare [4]. Training if future surgeons should provide obtaining and mastering not only of theoretical material, but also to build and improve specific practical skills, based on which in the future will depend a person life. [5-6].

Currently, the medical education institutions for teaching actively introduced innovative computer technology, such as online seminars (webinars), e-learning publications, automated testing tools, etc [7]. Most of them provide training and supervision of theoretical training. But it is also necessary to provide students with practical skills. Traditionally, medical educational institutions use practical exercises with the real anatomical structures-specimens (corpses) [8-9]. The use of biological material is related, in Ukraine on particular, with significant challenges, not only moral and ethical or financial, but also legal [10-11]. These and other factors have contributed to the emergence and development of medical simulators [12-13]. Some time later, with the development of computer technology appear virtual medical simulators. During training the learner, they allow you to provide all kinds of control [14-15].

Thus, two types of simulators can be distinguished:

– physical;

– virtual.

Virtual simulators have enormous number of advantages but at the same time they do not always provide reality of sensation. Physical simulators have one huge disadvantage, namely, they cannot be used for distance learning, especially in

Massive Open Online Courses (MOOC) [16-17]. Due to the complexity of providing for each student's of physical simulator.

It is therefore necessary to ensure the establishment of procedures for obtaining of simulators with the following properties:

– physical tactility of the object;

– the possibility of remote transmission for use in MOOC;

– variability and personalization of the object;

– the relative cheapness;

Thus, it is first necessary to analyze the existing technologies that provide rapid creation of an object and also they need to be relatively widely available.

Such a result can be achieved with use of rapid prototyping technology.

The study was conducted using the 3D-printer WANHAO Duplicator i3 (Fig. 1).

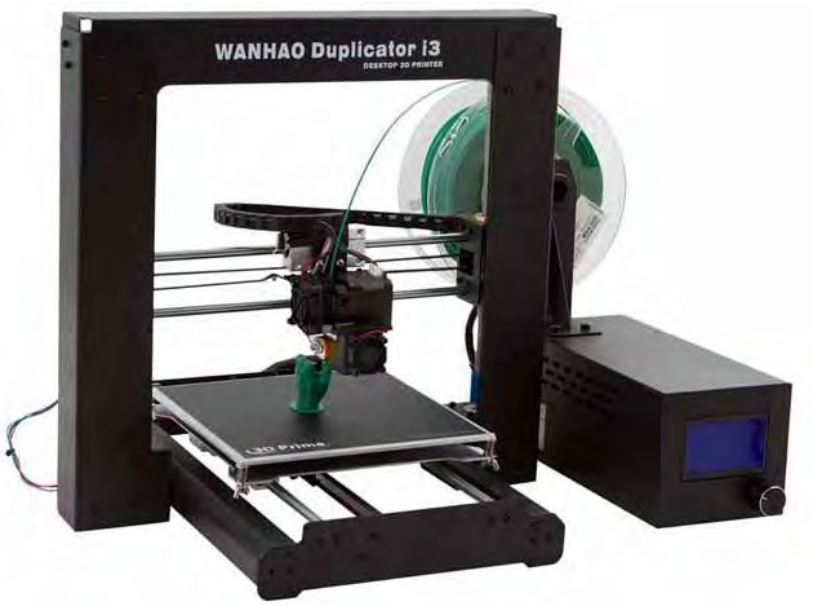



*Figure 1 – 3D Printer WANHAO Duplicator i3*

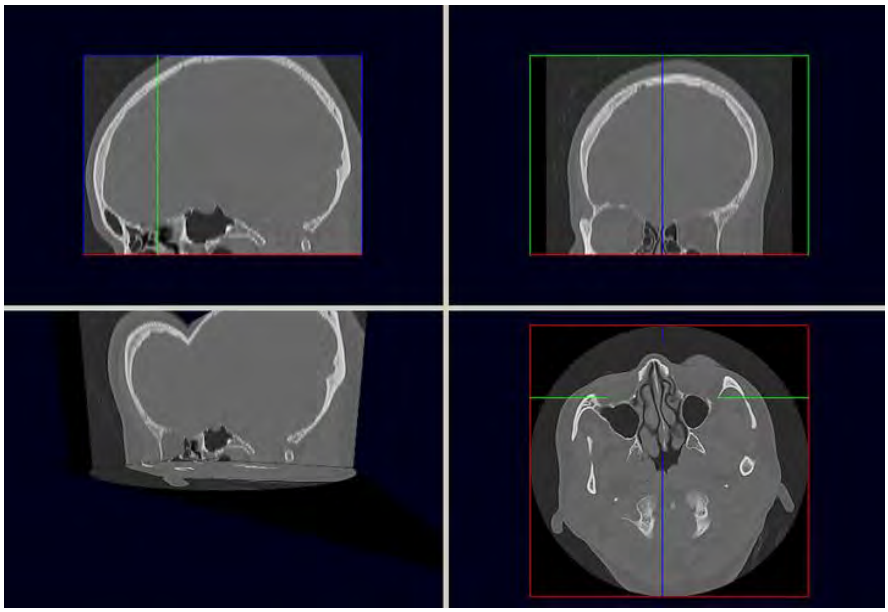
This 3D-printer allows you to build three-dimensional models in the volume equal to 200×200×180 mm. Resolution of slice is 0.1–0.4 mm, the accuracy in the XY plane is equal to 0.012 mm, and along the Z-axis is 0.004 mm.

The initial data is a set of CT slices of the head (Fig. 2). The distance between the slices is equal to 2 mm, the size of one pixel is 0.355 mm × 0.355 mm.

As object for the reconstruction is chosen a nasal cavity because it has a complex geometric configuration.

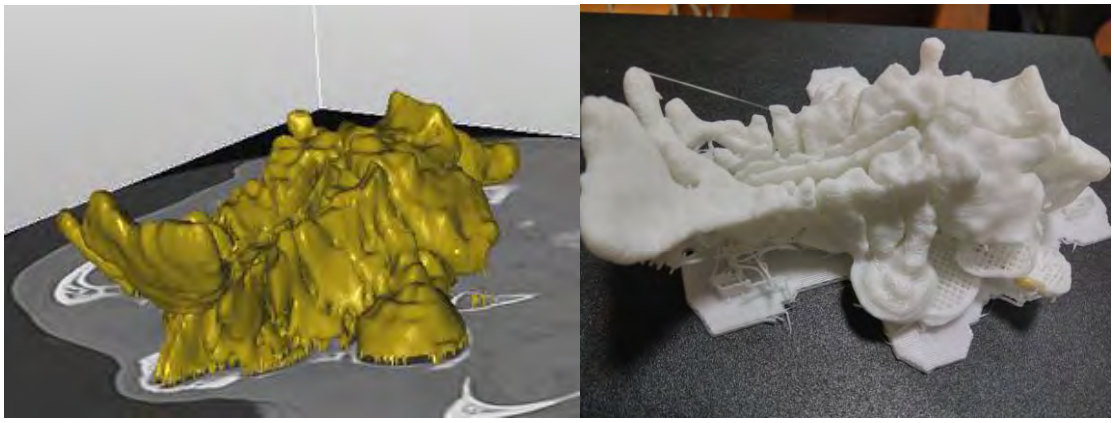
As can be seen from Fig. 2, airways have a low value of the X-ray density, due to the fact that they are filled with air. Therefore, to separate the reconstructed

structure is possible to use threshold segmentation. It provides a selection of structures with a particular X-ray density.



*Fugure 2 – An example of input DICOM dataset*

According to the threshold segmentation, we obtain a three-dimensional virtual model (Fig. 3 a).



a b

*Figure 3 – An example of the 3d reconstruction:*
*a – virtual 3d model of anatomical structure on the axial tomographic slice; b – printed 3d model of anatomical structure*

On the basis of the virtual three-dimensional model by sequentially fusing of material we made full-scale reconstruction of the object (Fig. 3 b).

The study shows the possibility of using rapid prototyping technology to address objectives of learning in the field of healthcare. The resulting full-scale structure can be used not only for theoretical study of the anatomical structure, but also to solve

practical problems, namely for training of preoperative planning processes, as well as directly for learning of surgical interventions. In addition, the described approach allows obtaining anatomical models of high precision, which can reflect all kinds of pathologies taking into account the individual characteristics. A promising direction for future research is the development and implementation an appropriate set of full-scale anatomical models for theoretical and practical education.

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## ОСОБЛИВОСТІ ЗАСТОСУВАННЯ ПРОТОКОЛУ OAI-PMH ДЛЯ ЗВЕДЕНИХ БІБЛІОТЕЧНИХ ЕЛЕКТРОННИХ КАТАЛОГІВ



***Розглянуто підходи для побудови зведених бібліотечних електронних каталогів та підкреслено складність їх організації в умовах різноманітного бібліотечного програмного забезпечення та форматів даних. Показано, що протокол збору метаданих OAI-PMH, що успішно застосовний для об'єднання та поширення цифрових ресурсів, застосовується і для об'єднання бібліографічних ресурсів з бібліотечних електронних каталогів.***

***Ключові слова: зведений бібліотечний електронний каталог, електронний каталог, OAI-PMH, агрегація метаданих, HTTP, XML.***

***The paper considers different models for building a union library catalogs and***