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M.U. Alimanova¹, A.B. Tursynbekova¹

¹Suleyman Demirel University, Kaskelen, Kazakhstan

CREATING THREE DIMENSIONAL INTERNAL ORGANS FOR SCANNING USING SIMULATOR

Abstract. The widespread use of information technology in various fields of science and education in many ways began to determine the progress and direction of development in these areas. A special place is occupied by medicine. This article discusses the solutions and further usage of the opportunities of three-dimensional modeling technology in medicine and in the study of the anatomical features of human internal organs. The field of computer visualization considered in the work, on the example of a designed human heart during medical practice, was focused on the final result on improving the quality of training of doctors at the present stage. The main task of the scientific work is the introduction of modern diagnostics and treatment of heart diseases based on a three-dimensional projection of the cardiovascular organ. Using this project increases the prospects for effective educational process in clinical departments, as well as during cardio-testing. In the process of creating a three-dimensional model, studies were conducted in search of a suitable method for the projection of internal organs with the most approximate accuracy. As a result of the study, a visual model of the human heart was developed that meets the requirements of a diagnostic scanner.

Keywords: computer modeling, 3D model of the human organ, visualization, augmented reality, computer simulation.

Аннотация. Широкое применение информационных технологий в различных областях науки и образования во многом стали определять прогресс и направление развития в этих сферах. Особое место занимает медицина. В статье рассматриваются решения и дальнейшее использование возможностей технологии трехмерного моделирования в медицине и при изучении анатомических особенностей внутренних органов человека. Рассматриваемая в работе область компьютерной визуализации, на примере спроектированного человеческого сердца во время врачебной практики, была ориентирована на конечный результат по улучшению качества подготовки врачей на современном этапе.

Основной задачей научной работы является внедрение современной диагностики и лечения болезней сердца на базе трехмерной проекции сердечно-сосудистого органа. Используя этот проект,

повышаются перспективы эффективного учебного процесса на клинических кафедрах, а также во время кардио-тестирования. В процессе создания трехмерной модели были проведены исследования в поиске подходящего метода проекции внутренних органов с максимально приближенной точностью. В результате исследования была разработана визуальная модель человеческого сердца, отвечающая требованиям диагностического сканера.

Ключевые слова: компьютерное моделирование, 3D модель человеческого органа, визуализация, дополненная реальность, компьютерная симуляция.

Андатпа. Ғылым және білім саласында ақпараттық технологияларды қолдану, таңдалған бағыттардың дамуын айқын көрсетіп жатыр. Бұл бағыттардың арасында медицинаның орын ерекше. Мақалада медицинадағы үш өлшемді модельдеу технологиясының адамның ішкі органдарының анатомиялық ерекшеліктерін зерттеу барысындағы мүмкіндіктері және қолдану әдісі қарастырылған. Жобадағы қарастырылған компьютерлік визуалдау аймағы, медицина практикасындағы адам жүрегісінің үлгісінде, қазіргі кезеңде дәрігерлерді даярлау сапасын жақсарту үшін бағытталған.

Ғылыми жобаның негізгі міндеті, жүрек-қан тамырлар органдарының үш өлшемді проекциясы негізінде жүрек ауруларын диагностикалау мен емдеудің заманауі әдістерін енгізу. Ұсынылған жобаны пайдалану клиникалық кафедраларда оқу болашағын және кардиологиялық тестілеу тиімділігін жоғарылатады. Үш өлшемді модель жасау барысында, ішкі органдардың проекциясын аса жоғары дәлдікпен кескіндеу әдісін табу үшін зерттеулер жүргізілді. Зерттеу нәтижесінде диагностикалық сканердің талаптарына сай, адам жүрегінің визуалды моделі жасалды.

Түйін сөздер: компьютерлік модельдеу, адамның ішкі органының 3D моделі, визуализация, толықтырылған шындық, компьютерлік симуляция.

Introduction

Modern information technologies find their application in solving a wide variety of tasks: from keeping a database of patients to complex diagnostic systems and software and hardware robotic surgery. One of the topical tasks of applying information technologies is the modeling of the human heart.

The relevance of this topic is caused by two main factors. The first of them is the extreme importance of the problem of cardiovascular disease. According to statistics, they confidently hold the first place among the causes of death and disability of the population. Diagnosis of cardiovascular diseases

is a major problem. The second factor is the ubiquitous introduction of information technologies, when modeling and analysis of the functioning of systems have become the norm today. The field of modeling the human heart at the junction of medical and technical disciplines. And as the history of science shows, at least from the middle of the last century, very often breakthroughs occur precisely when working at the junction of different industries. Recall at least the joint work of the famous scientist, cybernetics, Norbert Wiener and physiologist Arturo Rosenblueth. Many scientists and entire branches of science have successfully developed the subject of the heart, certain aspects of its activity, but often quite isolated from each other. The current level of development of information technology, modeling and visual allows the use of these lessons for research, training and diagnostics.

Diagnosis of the cardiovascular system of the future will be based on the modeling of electrical processes in the heart according to electrocardiographic data obtained on the surface of the body. In fact, they formulate the same goal - analysis of the heart model using the initial data of a real person. Assuming that there is an adequate model for the work of the heart, the analysis of the data here is obtaining parameters of such a model that reflects the characteristics of a particular person, and modeling is just an examination of the functioning of the heart on such a model, taking into account individual parameters. This can be called even a change in the diagnostic paradigm and the transition to diagnostics based on modeling (or simulated diagnostics), when the patient's diagnosed state is modeled taking into account his physiological characteristics. This approach is fully consistent with all world trends in the individualization of medicine, the introduction of personal medical profile, the long history of storage of diagnostic data and diagnostic results.

The basis for modeling the heart can be a model of electrical activity heart. A whole class of such models, in spite of significant differences, boils down to one - the examination of the heart as an electrical generator, such that when placed in the place of the heart, we could record on the surface of the body ECG with a satisfactory error.

There are many such models now: a point charge, a dipole, a quadrupole, a multipole or a multi-dipole generator, etc. Especially it is worth emphasizing the contribution to the development of such models of Russian scientists: V.S. Marhasin, L.I. Titomir, M.P. Roshchevsky, O.V. Baum, A.N. Volobuev and M.N. Kramm.

3D graphics and MRI data

Medical technologies throughout the existence of medicine an inescapable need for methods that would allow inside the human body without damaging it. It can be said that more than part of humanity has succeeded in solving this problem. However, in modern world of general awareness, the question is increasingly raised – how it is most possible to explain to the

patient the need for surgical intervention and peculiarities of the biological processes that occur with his body? The technology described in this article is extremely effective both for the treating doctors who face difficulties in describing and adapting complex medical terms and processes for patients, and for patients who are able to make sure that they need medical intervention and clearly assess the risks and extent of the problem. In some way, the patient becomes not just a competent listener, but also a kind of student doctor who, in an accessible language, sets out the a visual medical aid.

The basic principle used in the development is based on the creation of high detailed master-model of a healthy heart with all internal structures and textures. This model is used as a basis for further development of detailed models of patients' hearts with different defects. Depending on the kind of defects in the aftermath of the master a model is introduced that are characteristic of various pathologies. Idea of this principle is in advance to do most of the work and do not repeat it in the future, i.e., a highly detailed «Ideal» version of the body, and all further changes are made in the automatic mode already in the process of interaction of the master model with medical data of the patient. The process of creating a master-model consists in the MRI simulation of the data. Several healthy hearts of one final model. Using already prepared the averaged model was constructed. Further, this artists are working on 3D graphics together with doctors, to obtain an accurate shape with all surface details and internal structures such as trabecularity and valves that cannot be completely reconstructed from MRI data. After this, the artists reconstructed using a photo of real hearts. As a result, all this exact master model of the heart is obtained, which will be used as a basis (Fig. 1).

To imagine how to build a three-dimensional model of the human body from two-dimensional DICOM-files it is necessary to understand, as represented images in medicine. For example, it is important to take into account that all modern tomography do not produce finished images form a file in a special DICOM-format, containing information about the patient, research and information for drawing the image. Each file is a section of the necessary part of the body in a certain plane contains information of intensity and density of tissues in a given section. As a rule one study creates several files with a logical structure, which are combined in a series and represent a set of sequential slices of any organ. Series are combined in a stage, and the stage determines all research.

The next stage, when it is already necessary to specify the model and the image of the heart of a particular patient is taken from his MRI and contours. According to the MRI data, a rough model is built automatically. One very often, the heart MRI data is sufficiently noisy or low therefore, in addition to them, contour files are used. Contouring performed by a special doctor who knows anatomy heart and had a lot of experience in working with MRI data.

This is usually a procedure occurs always after creating MRI scan. The doctor manually outlines the strength layers of heart structures are layered and stores this data in a * .con file. Use these data allow one to build the model of the heart most reliably.



Fig.1 – Model of heart

To process contour files, a specialized pro-software that builds curves in space. By these curves the outer surface of the heart and the inner surfaces of the stomach are formed. Daughter model is understood as a basic blank for the real heart of the patient. A detailed master-model is then loaded, which projected onto this blank using fixed point that are the relationship between the patient's heart model and the master model. Such as you can use the detail of the master model, but thread the original shape of the internal and external structures of the patient's heart. By past this, it allows you to fill in the missing information that was taken from the patient's MRI data. Thus, we obtain a detailed a model of the heart that corresponds to the patient's heart shape and possesses the necessary with detailed detail and quality of textures (Fig. 2). Obviously, resulting thus obtained is not an ideally accurate three-dimensional re-patient's heart. However, within the limits of the set tasks, where it is necessary to explain the condition of the injured organ, relying on its anatomy, this solution is optimal. Among other things, this approach co-model building can be brought to automatic when the treating physician or the patient only needs to be given a command to generate CT and MRI data of model of the organ before and after the operation.

This automated approach makes it possible to build a three-dimensional remote, without additional intervention and correction of specialists' three-dimensional modeling. This means that this solution is possible use on a remote web server. Thus, it was decided to develop web resource that will process MRI and CT data and output giving the user a three-dimensional model

of the heart. The work of the web service is organized as follows: the first step the doctor loads the MRI / CT data on the server.

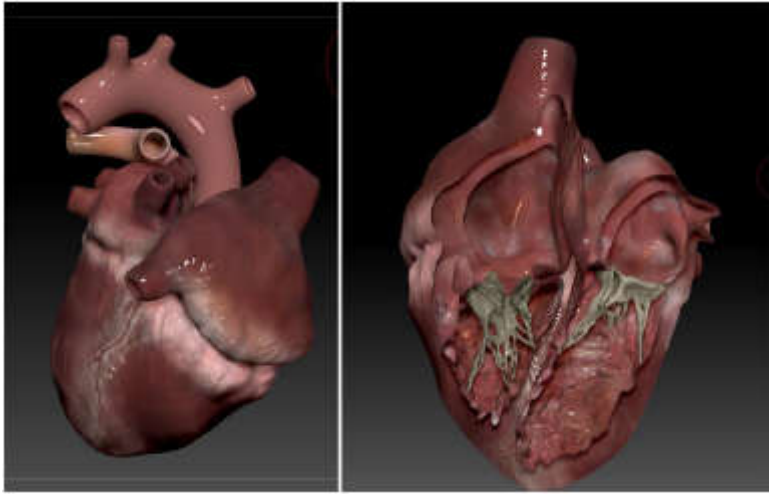


Fig.2 – Built model of patient with inner structure

On the server there is a data processing and the doctor, practically at once (on request) gets a ready model, which can be viewed in the browser, with it a number of manipulations, for example, to build a section, compare with the previous one with a healthy heart, rotate, scale and study with different angles. The next step is the loading of the MRI /CT body data into the web server after the surgical intervention. Data is being processed similarly and, upon request of the user, a three-dimensional model of the cured body. Among other things, an authorized resource user can compare both models and observe changes that occurred after the operation. The above solution allows an accessible and fast way to obtain 3D model, analyze it and, if necessary, even print that. However, it is also possible to supplement the set of solutions with the introduction of new the latest computer graphics technology in recent years. For example, this in the future, development can be improved with the help of full of reality (AR-technologies), which will provide opportunity of storage of all information on the three-dimensional model of the injured in the corresponding QR code. The use of complemented it can simplify the interaction and make the interface intuitive understandable. Also, it is obvious that AR-technologies are irreplaceable powerful presentation of complex structures and can act as an ideal an intermediate between a specialist (a doctor) and a consumer of the service (patient). The basic principle of this kind of technology is the combination of reality and virtual information, which, in our case, will be patient's three-dimensional heart.

Generation of 3D model using MRI scans

Imagine that you have done magnetic resonance imaging or computed tomography. The usual thing: a doctor looks at the tomograms for light - looks

for damage in the cranium and anomaly in its contents. In this situation, immediately comes the thought: it would be good to scan the results of tomography and make a full-scale three-dimensional model of your skull, which can be loaded into a 3D printer for printing. Oliver Krohn used three programs to create a 3D model. Two of them - Seg3D and ImageVis3D - are developed in the center of integrative biomedical computing at the University of Utah. The Seg3D program glues two-dimensional MRI or CT scans into the correct 3D format. The second program ImageVis3D allows you to edit the resulting file, clearing it of layers of unnecessary tissues (unnecessary in this task, of course).

In the end, Oliver used the universal editor MeshMixer, instead of which one could take MeshLab or Blender. Definitely, 3D-printing an exact copy of your skull is entertaining in itself. In addition, the model can come in handy in the future, in case of loss of the original. More precisely, in case of loss of its fragments or deformation. For example, in March 2014, surgeons from the University Medical Center of Utrecht for the first time in the world successfully transplanted the upper part of the skull, replacing it with a plastic implant printed on a 3D printer.

22-year-old girl from the Netherlands with a chronic bone disease - because of what the thickness of her skull increased by 1.5-5 cm, which caused visual disturbances and headaches - they installed a new organ made of translucent plastic. Experts have previously printed on the 3D printer fragments of the skull, but for the first time managed to transplant such a large implant, which was not torn away by the body. So it's not bad to have a digital 3D model of the skull.

Result

Summing up, it should be noted that the above described approach to creating 3D model of the heart, with all the accompanying tech can easily be adapted for visualization of other organs, using also the data of MRI and CT. Changes in the basic technology in this case, only the first stages of the technology will be master of the model it will be necessary to develop manually, by prototypes personal bodies average master-models for each of the selected objects the human body.

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