



PROSPECTS FOR CREATING COMPUTER- AND MRI-BASED 3D MODELS OF INTERNAL ORGANS IN EMERGENCY SURGERY AND RESUSCITATION

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ABSTRACT

The present article gives an analytical overview of the current state of processing problems and visualization of magnetic resonance imaging (MRI). It is presented the expediency of combining of instrumental means, presented in various open-source programs and scientific publications in recent years, into a single program- tool complex solving in full problems of pre-processing and filtering data, directed precision thematic segmentation and analysis of images, forming the feature space, recognition of the situation, 3D modeling, and visualization. The complex is designed for expert decision support of doctors-researchers in the process of carrying out scientific experiments. Support is based on the application of new methods of brain area texture analysis, effective metrics, and advanced means of cognitive computer graphics. An important feature of the complex must be the interactive operating mode of the doctor-researcher with MRI data, which can be provided by applying high-performance computing with software support of hardware accelerators.

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Introduction

Every day, the number of patients who are scheduled for diagnostic examination using a computer (CT) and magnetic resonance imaging (MRI) methods is growing [1].

In computed tomography, for example, of the abdominal cavity, it is difficult to separate the tumor from the organ, as well as to calculate its volume characteristics [2-4]. To make the right decision about surgery on a tumor, it is useful to have a clear 3D model [5-7].

However, modern software for processing images obtained during CT and MRI is developed and delivered with the devices, but the functions of these programs are not enough to perform complex operations with the obtained data [8-10].

Creating 3D models of organs using these programs is possible and difficult, but it requires a lot of time and system resources of computers directly connected to the tomograph. Also, existing SOFTWARE is not able to create 3D models of the internal structure of organs if the images were obtained without the use of contrast agents [11-17]. Also, no software allows you to simulate surgery to plan a real operation for a specific patient [18-21].

Currently, digital equipment of the largest manufacturers of radiological equipment (PICKER, GE, Siemens, HP, Philips) is widely used for diagnostic purposes [22-24]. This made it possible to determine the need to use the rapid transfer of data obtained during medical research between these centers, with the implementation of image processing capabilities to improve their analysis quality [25-28].

In connection with the above, for the use of computer technologies in medicine, there is a need for communication capabilities that would allow:

- network existing digital equipment to improve operational efficiency and reduce manual labor costs;
- ensure the extensibility of the existing network by connecting new equipment to it;
- integrate various data to improve the quality of diagnostics.

Universal computer network technologies do not allow combining different types of medical equipment [29-34]. Therefore, its manufacturers were forced to develop their communication interfaces. However, due to the wide range of medical equipment used by various companies, it became necessary to develop communication standards [19, 35-37].

This work aims to develop prototype software that allows you to create three-dimensional models of internal organs based on images of computer and magnetic resonance imaging with the possibility of simulating surgery and its use in emergency surgery and resuscitation.

Materials and Methods

When developing the software package, the following tasks were set:

1. The program should be built on a modular principle that allows you to build three-dimensional models of organs;
2. It should be possible to conduct an automated assessment of the form and volume of detected neoplasms;
3. The ability to integrate with the simulation module to perform preoperative simulation actions (incision and puncture).
4. The ability to design a system for integrating 3D models of organs obtained from medical images for bioprinting.
5. The ability to network existing digital equipment to improve operational efficiency and reduce manual labor costs.

The program interface should be adapted to users' tasks.

Various incoming DICOM files (an array of images with a certain distance between sections) obtained from a multispiral computer tomograph "Aguilion 160 Prime" by Toshiba were studied. Testing of the program takes place based on the Stavropol regional clinical consulting and diagnostic center in the Department of Radiation diagnostics (**Figure 1**).

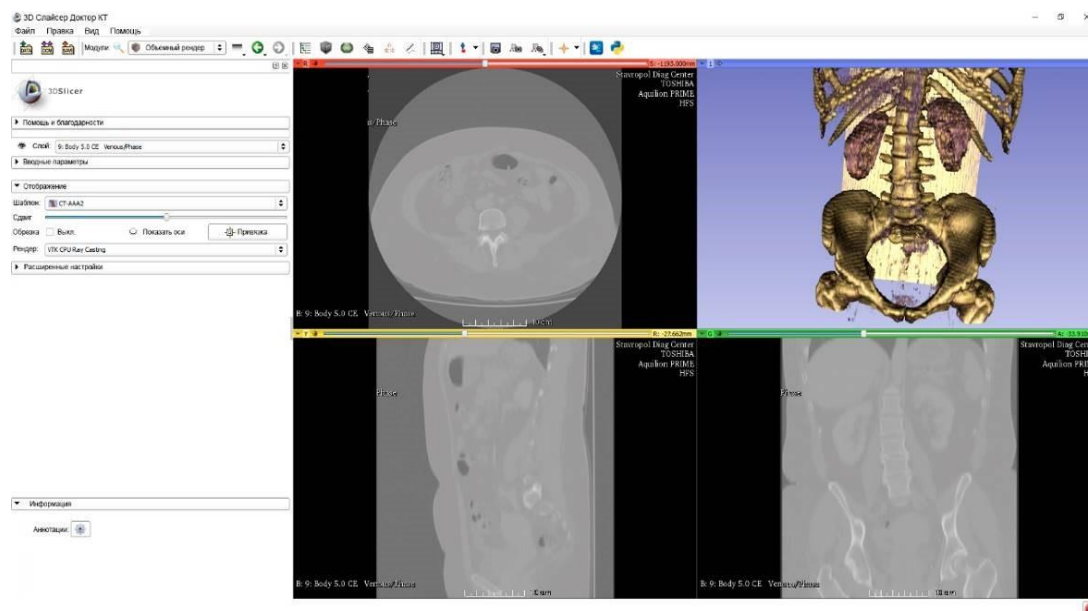


Figure 1. Software interface

Results and Discussion

Patient K., 39 years old, was sent to the magnetic resonance imaging office of the Department of Radiation diagnostics of the Stavropol regional clinical consultative and diagnostic center after consulting a neurologist with the diagnosis: withdrawal Epiprime. Right-sided pyramid syndrome. Dyscirculatory encephalopathy of the complex Genesis with scattered hot-spot symptoms. Dysmetabolic sensorimotor neuropathy. Based on our experience, it was hypothesized that the patient has an aneurysmal disease. This diagnosis is often manifested in an unbalanced and irrational diet. Prevention and correction of

nutrition in this diagnosis are discussed in our previous works [38-40]. Further analysis of the patient data was performed to confirm the diagnosis

From the anamnesis: a single convulsive attack on the background of alcohol withdrawal after prolonged use. There were complaints of headache, nausea, numbness in the extremities, tremor.

Preparation for the MRI: no specific preparation is required. The patient has explained the need to remain motionless while being in the magnet tunnel. The study was performed on a high-field MRI tomograph "PHILLIPS Ingenia 1.5 Tesla" using a standard scanning Protocol, including T1-VI, T2-VI, T2* - GRE, FLAIR, DWI with the construction of ADS maps, with a slice thickness of 5.0 mm, an inter-slice interval of 0.5 mm, in the axial, coronal and sagittal planes. Contrast enhancement was not performed. Also, to exclude aneurysmal disease, magnetic resonance. angiography (MRA) scanning with DICOM image analysis was performed.

In the future, the program modules were developed for analyzing DICOM files and building 3D models obtained as a result of their conversion. Then the program created three-dimensional reconstructions of organs and individual structures of the organ, the skeleton, blood vessels, and the surface of the organ. Was made a module for batch processing of an array of DICOM (Figures 2-4).

A module of a surgical intervention simulator was developed, where the resulting 3D model of an organ (kidney) was loaded into the module after reconstruction and allowed performing various manipulations: incision, puncture, scrolling the 3D model, zooming in and out of the organ model, tool setting mode (Figure 5).

New additional modules were developed for image reconstruction in 3D models with contrast agents. The software package can improve and automatically process medical images, and now the program is being tested without using contrast. The program allows you to perform pre-processing - tools with noise reduction and improve the quality of DICOM images. The control method is manual and semi-automatic.

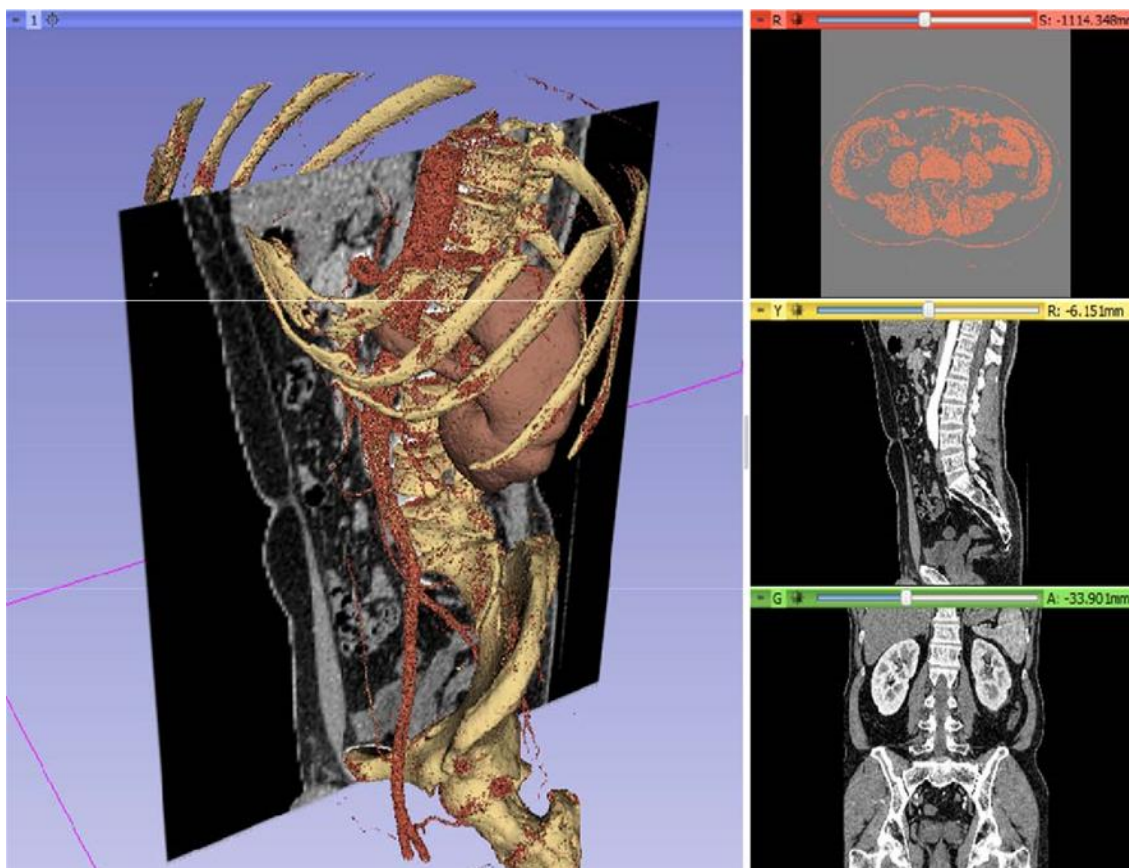


Figure 2. 3D reconstruction of the kidneys

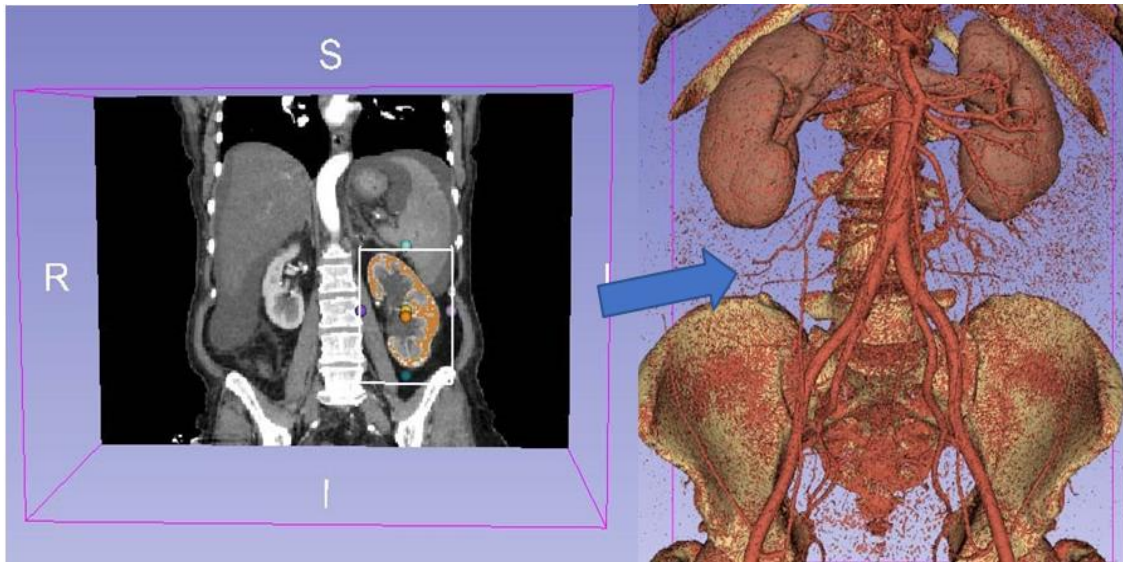
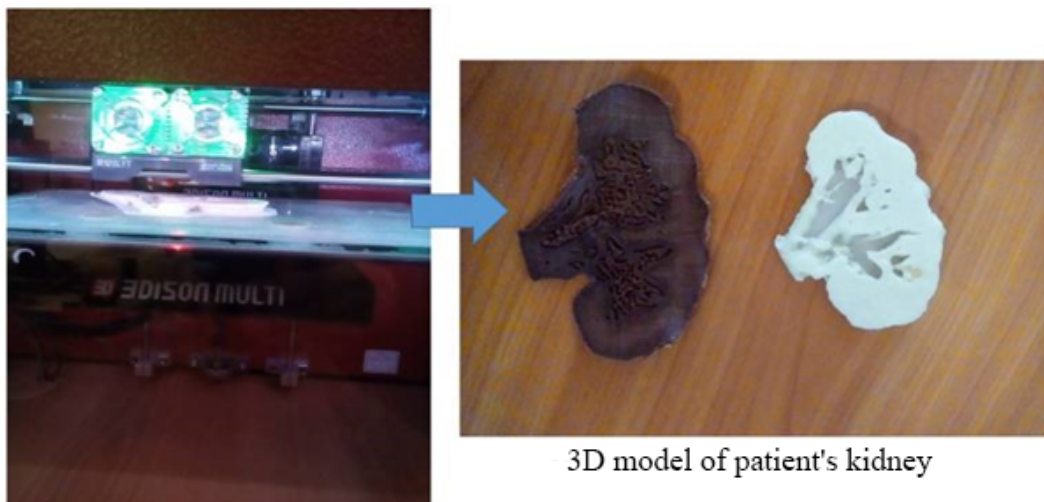


Figure 3. Software tools



Figure 4. Preoperative simulation of the surgical intervention

Also, using the software package, three-dimensional models of organs were printed on a 3D printer, in this case, human kidneys and heart were printed out using computed tomography (Figure 5).



3D model of patient's kidney

Figure 5. 3D printing of kidneys using DoctorCT

As a result of the work, the hypothesis of aneurysmal disease in the patient was excluded, which made it possible to prescribe conservative treatment. The software product is intended mainly for radiologists, radiologists, surgeons, and Cybernetics doctors. It can serve as a training program or simulator, and therefore will also be useful for young doctors who are practicing in medical centers and students studying at medical universities. The program is designed to simulate operational actions on internal organs

Conclusion

Studies were conducted on the possibility of building three-dimensional models of organs based on images obtained without the use of contrast agents. A positive result was obtained, but the method requires further development. Additional software modules are currently being developed to optimize image quality, build clearer organ structures in 3D models, and use modules and filters for various purposes for reconstructing three-dimensional models with or without contrast agents. For models using contrast agents, new materials based on nanoscale particles stabilized by active high-molecular compounds will be considered [7, 41, 42].

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References

1. Ezatpanah N, Majidi S, Keikhaee B. Investigation of Cardiac Complication of Sickle Cell Disease by Echocardiography and Mri. *Ann Dent Spec.* 2018;6(1):53-6.
2. Geng N, Augusto V, Xie X, Jiang Z. Experimental study of magnetic resonance imaging examination reservation process for stroke patients. In 2010 IEEE International Conference on Automation Science and Engineering 2010 Aug 21:774-9. IEEE. 10.1109/COASE.2010.5584021.
3. Bahaeldin HA, Ibrahim AL, Ahmed A, Ekhlash MH, Farida M. Regional Left Ventricular Function Analysis By 128-Row Multi-Detector Computed Tomography in Patients with Coronary Artery Disease. *Int J Pharm Res Allied Sci.* 2019;8(4):97-104.
4. Foroughi R, Gharouee H. Comparison of ultrasonography and computed tomography scan and sentinel node lymphoscintigraphy in diagnosis of metastatic cervical lymph nodes in patients with oral squamous cell carcinoma. *Ann Dent Spec.* 2018;6(3):308-10.
5. Geng N, Xie X. Simulation study of Magnetic Resonance Imaging examination reservation processes for stroke patients. In Proceedings of the 31st Chinese Control Conference 2012 Jul 25:2514-9. IEEE.
6. Nuzhnaya KV, Mishvelov AE, Osadchiy SS, Tsoma MV, AM RS KK, Rodin IA, et al. Computer simulation and navigation in surgical operations. *Pharmacophore.* 2019;10(4):46-52.
7. Blinov AV, Yasnaya MA, Blinova AA, Shevchenko IM, Momot EV, Gvozdenko AA, et al. Computer quantum-chemical simulation of polymeric stabilization of silver nanoparticles. Physical and chemical aspects of the study of clusters nanostructures and nanomaterials. 2019;11:414-21.
8. Snehkunj R, Jani AN, Jani NN. Brain MRI/CT images feature extraction to enhance abnormalities quantification. *Indian J Sci Technol.* 2018;11:1-12. doi:10.17485/ijst/2018/v11i1/120361
9. Bledzhyants GA, Mishvelov AE, Nuzhnaya KV, Anfinogenova OI, Isakova JA, Melkonyan RS, et al. The Effectiveness of the Medical Decision-Making Support System "Electronic Clinical Pharmacologist" in the Management of Patients Therapeutic Profile. *Pharmacophore.* 2019;10(2):76-81.
10. Areshidze DA, Mischenko DV, Makartseva LA, Kucher SA, Kozlova MA, Timchenko LD, et al. Some functional measures of the organism of rats at modeling of ischemic heart disease in two different ways. *Entomol Appl Sci Lett.* 2018;5(4):2349-864.
11. Demchenkov EL, Nagdalian AA, Budkevich RO, Oboturova NP, Okolelova AI. Usage of atomic force microscopy for detection of the damaging effect of CdCl₂ on red blood cells membrane. *Ecotoxicol Environ Saf.* 2021;208:111683.
12. Nagdalian AA, Pushkin SV, Povetkin S, Nikolaevich K, Egorovna M, Marinicheva MP, et al. Migalomorphic Spiders Venom: Extraction and Investigation of Biological Activity. *Entomol Appl Sci Lett.* 2018;5(3):60-70.
13. Nagdalyan AA, Selimov MA, Topchii MV, Oboturova NP, Gatina YS, Demchenkov EL. Ways to reduce the oxidative activity of raw meat after a treatment by pulsed discharge technology. *Res J Pharm Biol Chem Sci.* 2016;7(3):1927-32.
14. Nesterenko AA, Koshchayev AG, Keniiz NV, Shhalahov DS, Vilts KR. Effect of low frequency electromagnetic treatment on raw meat. *Res J Pharm Biol Chem Sci.* 2017;8(1):1071-9.

15. Cheboi PK, Siddiqui SA, Onyando J, Kiptum CK, Heinz V. Effect of Ploughing Techniques on Water Use and Yield of Rice in Maugo Small-Holder Irrigation Scheme, Kenya. *Agri Engineering*. 2021;3(1):110-7. doi:10.3390/agriengineering3010007
16. Siddiqui SA, Ahmad A. Dynamic analysis of an observation tower subjected to wind loads using ANSYS. In: *Proceedings of the 2nd International Conference on Computation, Automation and Knowledge Management (ICCAKM) [conference proceedings on the Internet]*; 2021 Jan 19-21; Dubai, United Arab Emirates. United Arab Emirates: IEEE; 2021 [cited 2021 Jan 19]. p. 6-11. Available from: IEEE Xplore
17. Siddiqui SA, Ahmad A. Implementation of Thin-Walled Approximation to Evaluate Properties of Complex Steel Sections Using C++. *SN Comput Sci [Internet]*. 2020 Oct [cited 2020 Oct 16];1(342):1-11. Available from: <https://link.springer.com/article/10.1007/s42979-020-00354-1>. doi:10.1007/s42979-020-00354-1
18. Hite GJ, Mishvelov AE, Melchenko EA, Vlasov AA, Anfinozenova OI, Nuzhnaya CV, et al. Holodocor Planning Software Real-Time Surgical Intervention. *Pharmacophore*. 2019;10(3):57-60.
19. Luneva A, Koshchayev A, Nesterenko A, Volobueva E, Boyko A. Probiotic potential of microorganisms obtained from the intestines of wild birds. *Int Trans J Eng Manag Appl Sci Technol*. 2020;11(12):11A12E
20. Nagdalian AA, Rzhepakovsky IV, Siddiqui SA, Piskov SI, Oboturova NP, Timchenko LD, et al. Analysis of the Content of Mechanically Separated Poultry Meat in Sausage Using Computing Microtomography. *J Food Compos Anal*. 2021;100:103918. doi:10.1016/j.jfca.2021.103918
21. Salins SS, Siddiqui SA, Reddy SVK, Kumar S. Parametric Analysis for Varying Packing Materials and Water Temperatures in a Humidifier. In: *Proceedings of the 7th International Conference on Fluid Flow, Heat and Mass Transfer (FFHMT'20) [conference proceedings on the Internet]*; 2020 Nov 15-17; Niagara Falls, Canada. Canada: FFHMT; 2020. p. 196(1)-196(11). Available from: FFHMT
22. Ali MA, Raslan HM, Abdelhamid MF, Mohamed M, Fawzy HA, Abdelraheem HM, et al. Serum levels of Osteoprotegerin, Matrix Metalloproteinase-III and C-reactive protein in patients with Psoriasis and Psoriatic Arthritis and their correlation with Radiological findings. *J Adv Pharm Educ Res*. 2019;9(1):88-92.
23. Siddiqui SA, Ahmad A. Implementation of Newton's Algorithm Using FORTRAN. *SN Comput Sci [Internet]*. 2020 Oct [cited 2020 Oct 17];1(348):1-8. Available from: <https://link.springer.com/article/10.1007/s42979-020-00360-3#citeas>. doi:10.1007/s42979-020-00360-3
24. Salins SS, Shetty S, Siddiqui S. Determination of Power in Hydroelectric Plant Driven by Hydram: A Perpetual Motion Machine Type 1. *Int J Multidiscip Res Mod Educ (IJMRME)*; ISSN (Online): 2454 – 6119 [Internet]. 2015 Aug [cited 2015 Aug 19];1(1):115-22. Available from: <http://rdmodernresearch.org/wp-content/uploads/2015/08/14.pdf>
25. Salins SS, Siddiqui SA, Reddy SVK, Kumar S. Experimental investigation on the performance parameters of a helical coil dehumidifier test rig. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects [Internet]*. 2021 Apr [cited 2021 Apr 9];43(1):35-53. Available from: <https://www.tandfonline.com/doi/full/10.1080/15567036.2020.1814455>
26. Osipchuk GV, Povetkin SN, Ashotovich A, Nagdalian IA, Rodin MI, Vladimirovna I, et al. The issue of therapy postpartum endometritis in sows using environmentally friendly remedies. *Pharmacophore*. 2019;10(2):82-4.
27. Morozov VYu, Kolesnikov RO, Chernikov AN. Effect from Aerosol Readjustment Air Environment on Productivity and Biochemical Blood Parameters of Young Sheep. *Res J Pharm Biol Chem Sci*. 2017;8(6):509-14.
28. Keniiz NV, Koshchaev AG, Nesterenko AA, Omarov RS, Shlykov SN. Study the effect of cryoprotectants on the activity of yeast cells and the moisture state in dough. *Res J Pharm Biol Chem Sci*. 2018;9(6):1789-96.
29. Blinova A, Blinov A, Baklanova O, Yasnaya M, Baklanov I, Siddiqui A, et al. Study of Wound-Healing Ointment Composition based on Highly Dispersed Zinc Oxide Modified with Nanoscale Silver. *Int J Pharm Phytopharmacol Res*. 2020;10(6):237-45.
30. Khoperskov AV, Kovalev ME, Astakhov AS, Novochadov VV, Terpilovskiy AA, Tiras KP, et al. Software for full-color 3D reconstruction of the biological tissues internal structure. In *International Conference on Health Information Science*. 2017:1-10. Springer, Cham. doi:10.1007/978-3-319-69182-4_1
31. Sizonenko MN, Timchenko LD, Rzhepakovskiy IV, DA SP AV, Nagdalian AA, Simonov AN, et al. The New Efficiency of the «Srmp»–Listerias Growth-Promoting Factor during Factory Cultivation. *Pharmacophore*. 2019;10(2):85-8.
32. Pushkin, SV, Tsymbal, BM, Nagdalian, AA, Nuzhnaya, KV, Sutaeva, AN, Ramazanova, SZ, et al. The Use of Model Groups of Necrobiont Beetles (Coleoptera) for the Diagnosis of Time and Place of Death. *Entomol Appl Sci Lett*. 2019;6(2):46-56.
33. Lopteva MS, Povetkin SN, Pushkin SV, Nagdalian AA. 5% Suspension of Albendazole Echinacea Magenta (Echinacea Purpurea) Toxicometric Evaluation. *Entomol Appl Sci Lett*. 2018;5(4):30-4.
34. Nesterenko AA, Koshchaev AG, Keniiz NV, Shhalahov DS, Viltis KR. Development of device for electromagnetic treatment of raw meat and starter cultures. *Res J Pharm Biol Chem Sci*. 2017a;8(1):1080-5.
35. Murphy SV, Atala A. 3D bioprinting of tissues and organs. *Nat Biotechnol*. 2014;32(8):773-85. doi:10.1038/nbt.2958
36. Selimov MA, Nagdalian AA, Povetkin SN, Statsenko EN, Kulumbekova IR, Kulumbekov GR, et al. Investigation of CdCl₂ Influence on red blood cell morphology. *Int J Pharm Phytopharmacol Res*. 2019;9(5):8-13.

37. Saleeva IP, Morozov VY, Kolesnikov RO, Zhuravchuk EV, Chernikov AN. Disinfectants effect on microbial cell. Res J Pharm Biol Chem Sci. 2018;9(4):676-81.
38. Nagdalyan AA, Oboturova AP, Povetkin SN, Ziruk IV, Egunova A, Simonov AN, et al. Adaptogens Instead Restricted Drugs Research for An Alternative Itemsto Doping In Sport. Res J Pharm Biol Chem Sci. 2018;9(2):1111-6.
39. Omarov RS, Shlykov SN, Nesterenko AA. Obtaining a biologically active food additive based on formed elements blood of farm animals. Res J Pharm Biol Chem Sci. 2018;9(6):1832-8.
40. Sadovoy VV, Selimov MA, Slichedrina TV, Nagdalian AA. Usage of biological active supplements in technology of prophylactic meat products. Res J Pharm Biol Chem Sci. 2016;7(5):1861-5.
41. Blinov AV, Kravtsov AA, Krandievskii SO, Timchenko V, Gvozdenko AA, Blinova A. Synthesis of MnO₂ Nanoparticles Stabilized by Methionine. Russ J Gen Chem, 2020;90(2):283-6.
42. Barabanov PV, Gerasimov AV, Blinov AV, Kravtsov AA, Kravtsov VA. Influence of nanosilver on the efficiency of *Pisum sativum* crops germination. Ecotoxicol Environ Saf. 2018;147:715-9. doi:10.1016/j.ecoenv.2017.09.024