Federal state budget educational institution of higher education
SIBERIAN STATE MEDICAL UNIVERSITY
Ministry of Health of the Russian Federation

APPROVED BY

Dean of Biomedicine Department
_______________/ Svetlana V. Gusakova
"____" ____________2020

Для справок
и выписок
из документов

Course Name:

MATHEMATICAL METHODS FOR IMAGING IN MEDICINE

Field of study: Nuclear Science and Technology

Programme name: Nuclear Science and Technology

Specialization: Nuclear medicine

Level of study: Master Degree Programme

Semester, year: semester 2, year 1

Tomsk 2020

TOMSK POLYTECHNIC UNIVERSITY
ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

APPROVED BY

Director of Nuclear Science & Engineering School
______________ Oleg Yu. Dolmatov
"25" 06 2020

Course Name: Mathematical Methods for Imaging in Medicine

Field of study: Nuclear Science and Technology

Programme name: Nuclear Science and Technology

Specialization: Nuclear medicine

Level of study: Master Degree Programme

Year of admission: 2019

Semester, year: semester 2, year 1

ECTS: 2

Total Hours: 72

Contact Hours: 32

- **Lectures:** 8
- **Lab:** 24

Self-study: 40

Assessment: Exam, graded credit-test

Division: Biomedicine Department of Siberian State Medical University

Director of Programme ______________________ / Vera V. Verkhoturova

Instructor ______________________ / Konstantin S. Brazovskii

TOMSK POLYTECHNIC UNIVERSITY ТОМСКИЙ ПОЛИТЕХНИЧЕСКИЙ УНИВЕРСИТЕТ

Course Name: Mathematical Methods for Imaging in Medicine

Course overview:

Course Objectives	The objective of the course is to study recent mathematical methods to obtain and process medical images. The course is aimed at students to gain understanding of mathematical methods to obtain and process 2D and 3D medical images; to master basics of processing of medical images, and to study the best practices to provide high quality of medical images.
Learning Outcomes	**Upon completion of the course, a graduate will obtain the knowledge of:** - basics of mathematical methods to obtain and process medical images; - methods of image processing of 2D and 3D images; - typical modality of medical images; - specific and general purpose software to process medical images. **Upon completion of the course, graduates are expected to develop the following skills:** - to use mathematical methods to process medical images; - to use the appropriate equipment and software to obtain and process medical images; - to obey the technical guidelines and annual maintenance procedures to guarantee both safety and efficiency of medical imaging equipment; - to apply automatic methods of image recognition and interpretation. **Upon completion of the course, graduates should acquire the practical experience in:** - using image processing methods and software to treat medical 2D and 3D images; - planning annual maintenance and emergency procedures to provide appropriate technical service for medical imaging equipment; - use of the specific and general purpose software to process medical images.
Course Outline	The training course is delivered through the following teaching modes: – 4 lectures; – 7 laboratory works. The course consists of 3 sections, which are given below. **Section 1. The fundamentals of medical imaging.** **Section 2. Mathematical methods to obtain and process medical images.** **Section 3. Applications of methods to obtain and reconstruct medical images.** Each section includes one or two lectures and two or three practical experiences. The course includes 1 seminar with test and case study report. The test consists of 10 questions with one correct answer. The test is rated at 2 points. The case study report describes a real situation along with supportive questions to substantiate the conclusion. The case report is rated at 2 points. Overall, the seminar gives up to 4 points. Students perform 11 lab-based reports upon completion of the laboratory works. The training course ends with an exam, which is rated at a maximum of 20 points.
Course Structure	The training course includes 3 sections: **Section 1. The fundamentals of medical imaging.** **Section 2. Mathematical methods to obtain and process medical images.** **Section 3. Applications of methods to obtain and reconstruct medical images.**

Section 1. The fundamentals of medical imaging

Physics and mathematical foundations of medical imaging. Introduction to theory of interaction of physical fields with biological objects during visualization. Fundamentals of tomographic images reconstruction and three-dimensional visualization.

Topics of lectures:

Lecture 1. The fundamentals of medical imaging

Topics of laboratory works:

Laboratory work 1. Radon conversion and reconstruction of x-ray tomographic images using a two-dimensional phantom.

Laboratory work 2. Modeling the process of magnetic resonance medical imaging. Scanning sequences and visualized values.

Laboratory work 3. Modeling ultrasound imaging. Studying the penetration depth of ultrasonic waves into biological tissues depending on frequency. Dopplerography.

Section 2. Mathematical methods to obtain and process medical images

Two- and three-dimensional digital filters. Types and characteristics of linear filters. Multidimensional discrete Fourier transform. Noise reduction and brightness equalization on medical images. The basic principles of intelligent image processing: contour recognition and calculation of geometric dimensions. Neural network based image recognition algorithms.

Topics of lectures:

Lecture 2. Filtering and noise reduction in medical images.

Lecture 3. Neural networks as a tool for recognizing anatomical structures.

Topics of laboratory works:

Laboratory work 4. Apply linear image filtering, anti-aliasing and border emphasis filters. Gaussian filter

Laboratory work 5. Multidimensional discrete Fourier transform as a universal tool to analyze and process medical images

Laboratory work 6. Studying the ability of neural networks to detect pathological structures

Section 3. Applications of methods to obtain and reconstruct medical images

Practical considerations on medical imaging. Typical issues and solutions. Obtaining, processing, applications and examples of 2D radiographs, computer X-ray tomograms, magnetic resonance and ultrasound images.

Topics of lectures:

Lecture 4. Applications of methods to obtain and reconstruct medical images.

Topics of laboratory works:

Laboratory work 7. Automatic processing of medical images: finding contours of the lungs, loci with increased density, loci of multiple sclerosis in a magnetic resonance images.

Topics for the term paper performed by students during the course study include:

1. Computed x-ray tomography. The key characteristics of X-ray imaging machines.
2. Factors influencing quality of X-ray medical images.
3. Contrasting agents and their applications for X-ray imaging.
4. The basics of computed tomography. Image reconstruction and processing techniques.
5. Magnetic resonance imaging. The key characteristics of MRI machines.
6. Factors influencing quality of MRI medical images.
7. The basics of MRI imaging. Image reconstruction and processing techniques.

	8. Ultrasound imaging machines. Principles of construction and operation. 9. Ultrasound tomography. Automated image processing and classification. 10. Manual and automated fine-tuning of medical images appearance: brightness, contrast, saturation. 11. Adaptive methods to correct contrast and brightness. Image histogram equalization. 12. Algorithms for automated image segmentation. Searching pathological loci in medical images.
Facilities and Equipment	Teaching of the course is conducted at the Siberian State Medical University. The educational process is supplied by the following facilities and equipment: – Classroom for all types of training sessions, consultations, ongoing monitoring and interim certification (classroom): 634034, Tomsk region, Tomsk, Moskovsly tract, 2/7, office 610 - Chalkboard-1 PC., student table-8 PCs., chair-18 PCs., TV panel - 1 PC., laptop - 1 PC.
Grading Policy	In accordance with TPU rating system we use: - Current assessment which is performed on a regular basis during the semester by scoring the quality of mastering of theoretical material and the results of practical activities during seminars (performance tests, case-tasks). Max score for current assessment is 80 points, min – 44 points. - Course final assessment (exam) is performed at the end of the semester. Max score for the course final assessment is 20 points, min – 11 points. The final rating is determined by summing the points of the current assessment during the semester and examination scores at the end of the semester. Maximum overall rating corresponds to 100 points, min pass score is 55 points.
Course Policy	Class attendance will be taken into consideration when evaluating students' participation in the course. Students are expected to actively engage in class discussions about the assigned readings. Attendance is strictly controlled. All classes require obligatory presence.
Teaching Aids and Resources	**Compulsory reading:** 1. Burbridge, B. Undergraduate Diagnostic Imaging Fundamentals / B. Burbridge, E. Mah. – Montreal : University of Saskatchewan, 2017. - 743 p. - Текст: электронный // Open Textbook Library. – URL: https://open.umn.edu/opentextbooks/textbooks/undergraduate-diagnostic-imaging-fundamentals (дата обращения: 20.09.2020). – Режим доступа: по подписке. 2. Hendee, W. R., Ritenour, E. R. Medical Imaging Physics / W. R. Hendee, E. R. Ritenour. - Fourth Edition. - New York: Wiley Liss, 2002. - 512 p. - Текст: электронный // Wiley Online Library. – URL: https://onlinelibrary.wiley.com/doi/book/10.1002/0471221155 (дата обращения: 20.09.2020). – Режим доступа: по подписке. 3. Prasad K. Fundamentals of Evidence-Based Medicine / K. Prasad. - Second Edition. – New Delhi: Springer, 2013. - 165 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/978-81-322-0831-0 (дата обращения: 20.09.2020). Режим доступа: по подписке. **Additional reading:** 1. Saha, Gopal B. Basics of PET Imaging: Physics, Chemistry, and Regulations / Gopal B. Saha. – New York: Springer Science+Business Media, Inc., 2005. - 219 p. - Текст: электронный // SpringerLink. – URL: https://link.springer.com/book/10.1007/b138655 (дата обращения: 20.09.2020). Режим доступа: по подписке.

	2. Hamidreza Mahboobi. Evidence- Based Medicine for Medical / Hamidreza Mahboobi, Sharma Akshay, Khorgoei Tahereh, Keramat Allah Jahanshahi [and etc.] //Australasian Medical Journal. - 2010. – № 3. – P. 190-193. - URL: https://www.researchgate.net/publication/43655583_Evidence-_Based_Medicine_for_Medical_Students (дата обращения: 20.09.2020). — Режим доступа: свободный доступ из сети Интернет. - Текст : электронный. **Internet resources:** 1. ELS SSMU: Access mode: http://irbis64.medlib.tomsk.ru 2. ELS "Book-Up»: Access mode: http://books-up.ru 3. ELS «Lan'»: Access mode: http://e.lanbook.com 4. ELS «Urayt»: Access mode: http://www.biblio-online.ru 5. Springer: Access mode: http://link.springer.com 6. EBSCOhost MEDLINE with Full Text: Access mode: http://search.ebscohost.com 7. ClinicalKey: Access mode: https://www.clinicalkey.com 8. PubMed (Medline): Access mode: http://pubmed.com or http://www.ncbi.nlm.nih.gov/pubmed 9. Science: Access mode: http://www.sciencemag.org 10. ScienceDirect: Access mode: http://www.sciencedirect.com
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