DESCRIPTION OF COURSE UNIT FOR DOCTORAL STUDIES
AT VILNIUS UNIVERSITY
(Interdisciplinary course)

Scientific Area/eas, Field/ds of Science	Medicine and health sciences (M 000): Medicina (M 001) Lealth sciences (N 000): Informatics (N 009), Biology (N 010)			
Faculty, Institute, Department/Clinic	Faculty of Medicine Institute of Biomedical Sciences Department of Pathology, Forensic Medicine and Pharmacology			
Course unit title (ECTS credits, hours)	**Computational Pathology and Artificial Intelligence Solutions** 6 credits (162 hours)			
Study method	**Lectures**	**Seminars**	**Consultations**	**Self-study**
Number of ECTS credits	0.5	0.5	1	4
Method of the assessment (in 10 point system)	Presentation and evaluation of oral presentation of a written report: the report is presented on a topic, which is assigned by the coordinating lecturers (the doctoral student must analyze, review and present the latest scientific publications related to the respective topic). The topic is assigned by the consulting lecturers 2 months before the delivery date. Duration of the presentation - up to 30 minutes. Criteria for evaluating the report (minimum acceptable score - 5): 1) novelty and relevance of the reviewed material to the chosen topic (2.5 points); 2) general structure and scope of the report, clarity, argumentation, conciseness and specificity (2 points); 3) summary, presentation and justification of conclusions (1 point); 4) raising problematic questions, presenting the application of the reviewed knowledge in the dissertation (3 points); 5) presentation of visual aids reflecting the essence of the topic (0.5 points); 6) ability to discuss topics related to the report (0.5 points) 7) answers to additional questions (0.5 points).			

PURPOSE OF THE COURSE UNIT

To get acquainted with the methods and applications of computational pathology and artificial intelligence based on digital image data of biological tissues. The subject is intended for doctoral students who seek to delve into biological tissue research based on image analysis, computational, and AI methods. The subject deals with the methods used in the field of tissue pathology.

THE MAIN TOPICS OF COURSE UNIT

Significance, advantages and problems of tissue-based biomarkers and pathology features of diseases for research and clinical applications in personalized therapy. General pathology processes (injury, inflammation, immunopathology, neoplasia) as basis of disease development. Prognostic and predictive markers of disease. Spatial heterogeneity in the expression of biological tissue and markers, the concept of tissue microenvironment.

Principles of tissue pathology research, bioethical aspects and technologies. Use of residual tissue for research. Research biobanks, principles of their organization. Preparation of biological tissues for examination, importance of preanalytical test phase, in particular, for digital image analyses. Histochemical, immunofluorescence, immunohistochemical, and molecular methods. Sources of variance, tissue artefacts, and quality assurance.
Virtual (digital) microscopy technologies. Imaging modes used in tissue pathology and research. Digital microscopy image formats, compression and information storage features. Impact of microscopic scanning equipment and settings on image analysis. Image processing before analysis. Fundamentals, advantages and limitations of digital image analysis. Color spectrum scales. Light intensity. The main algorithms of digital image analysis, their applications. Detection, segmentation, feature extraction, measurements. Principles of algorithm validation. The concept of ground truth (standard criterion) for analytical and clinical validation. Intra- and inter observer variation in the context of computational pathology. Principles of stereology, their application to generate ground truth and ensure the quality of microscopic image analysis. Principles of machine learning and deep learning. Supervised and unsupervised learning in pathology. Integration of various types of image analysis and other data.

Processing and use of digital microscopy data to develop predictive models of a disease. Explicit and implicit models. Use of image analysis outputs for multidimensional and spatial statistical methods. Use of data dimensionality reduction and clustering to process image-generated data. Deep learning methods for developing predictive models of a disease. The problem of interpretability artificial intelligence-based models in clinical medicine and potential solutions. Artificial intelligence systems in pathology validated for clinical use.

RECOMMENDED LITERATURE SOURCES

1. Perspectives on digital pathology // Editors Garcia-Rojo M, Blobbel B, Laurinavicius A. Stud Health Technol Inform 2012.
2. Janowczyk A, Madabhushi A. Deep learning for digital pathology image analysis: A comprehensive tutorial with selected use cases. J Pathol Inform. 2016; 7:29.
3. Madabhushi A, Lee G. Image analysis and machine learning in digital pathology: Challenges and opportunities. Medical image analysis. 2016; 33:170-5.
4. Campanella G, Hanna MG, Geneslaw L, Miraflor A, Werneck Krauss Silva V, Busam KJ, et al. Clinical-grade computational pathology using weakly supervised deep learning on whole slide images. Nature medicine. 2019; 25(8):1301-9.
5. Topol EJ. High-performance medicine: the convergence of human and artificial intelligence. Nature medicine. 2019; 25(1):44-56.
6. Hagele M, Seegerer P, Lapuschkin S, Bockmayr M, Samek W, Klauschen F, et al. Resolving challenges in deep learning-based analyses of histopathological images using explanation methods. Sci Rep. 2020; 10(1):6423.
7. Parwani AV, Amin MB. Convergence of Digital Pathology and Artificial Intelligence Tools in Anatomic Pathology Practice: Current Landscape and Future Directions. Advances in Anatomic Pathology. 2020; 27(4):221-6.
8. Weisberg EM, Chu LC, Park S, Yuille AL, Kinzler KW, Vogelstein B, et al. Deep lessons learned: Radiology, oncology, pathology, and computer science experts unite around artificial intelligence to strive for earlier pancreatic cancer diagnosis. Diagn Interv Imag. 2020; 101(2):111-5.
9. Baxi V, Edwards R, Montalto M, Saha S. Digital pathology and artificial intelligence in translational medicine and clinical practice. Mod Pathol. 2021.

10. Jackson BR, Ye Y, Crawford JM, Becich MJ, Roy S, Botkin JR, et al. The Ethics of Artificial Intelligence in Pathology and Laboratory Medicine: Principles and Practice. Acad Pathol. 2021; 8.
11. Latonen L, Ruusuvuori P. Building a central repository landmarks a new era for artificial intelligence-assisted digital pathology development in Europe. Eur J Cancer. 2021; 150:31.
12. Laurinavicius A, Rasmusson A, Plancoulaine B, Shribak M, Levenson R. Machine-learning-based evaluation of intratumoral heterogeneity and tumor-stroma interface for clinical guidance. Am J Pathol. 2021.

CONSULTING LECTURERS

1. Coordinating lecturer: Arvydas Laurinavičius (Prof. dr.)
2. Allan Rasmusson (Assoc. prof. dr.)
3. Mindaugas Morkūnas (Assist. prof. dr.)
4. Aida Laurinavičienė (Assoc. prof. dr.)

APPROVED:

By Council of Doctoral School of Medicine and Health Sciences at Vilnius University 15th of June, 2022

Chairperson of the Board: Prof. Janina Tutkuvienė