DOCTORAL STUDIES COURSE UNIT DESCRIPTION

Name of subject	Scientific Field	Faculty	Center/Institute/ Department
Image and Data Analysis (8 ECTS credits)	Physics N 002	Faculty of Physics	Institute of Theoretical Physics and Astronomy
Student's workload	Hours	Student's workload	Hours
Lectures	10	Consultations	15
Individual study	160	Seminars	15

Course annotation
Artificial neural networks and their application for image and data analysis. Python programming language. Working with image and data analysis libraries and their practical application. Automation of experimental data processing. Types and formats of digital images, multidimensional images. Intensity scale, contrast, color representation. Detector types, imaging and flat-fielding. Interactive and automatic image analysis. Arithmetic and geometric image transformations. Object detection, recognition, and classification. Geometric and photometric measurements. Photon noise-limited measurements. Point spread function. Image enhancement techniques. Removal of noise, distortions, and defects. Deconvolution. Spatial and frequency filters. Fourier decomposition. Wavelet transforms. Multi-scale image analysis. Measurement uncertainties and their sources. Discrete and continuous random variables. Probability density distributions, random number generation. Data samples and statistical hypothesis tests. Sample completeness and confidence limits. Linear and non-linear methods of least squares. Levenberg-Marquardt algorithm. Genetic algorithm. MCMC methods with fixed and variable number of free parameters. Optimization of model parameters and their confidence limits. Bayesian inference. Outlier detection. Covariance and correlation. Data filtering. Cluster analysis. Detection of regularities in multi-parametric data.
List of literature
1. Chityala R., Pudipeddi S. Image Processing and Acquisition using Python. Chapman and Hall/CRC. 2020. 451 p. 2. Dey S. Python Image Processing Cookbook. Packt. 2020. 438 p. 3. VanderPlas J. Python Data Science Handbook. O'Reilly Media, Inc. 2016. 548 p. 4. Kaggle Learn Course https://www.kaggle.com/learn 5. Hogg D. W. et al. Data analysis recipes: Fitting a model to data. 2010. arXiv:1008.4686. 6. Russ J. C., Neal F. B. The Image Processing Handbook. CRC Press. 2015. 1175 p. 7. Ivezić Ž. et al. Statistics, Data Mining, and Machine Learning in Astronomy: A Practical Python Guide for the Analysis of Survey Data. Princeton University Press. 2014. 552 p. 8. Chollet F. Deep Learning with Python, Second Edition. Manning Publications. 2021. 504 p.

Consulting teachers	Scientific degree	Pedagogical name	Main scientific works published in a scientific field in last 5-year period
Donatas Narbutis	PhD	Doc.	1. Bialopetravičius J., Narbutis D., 2020, Study of Star Clusters in the M83 Galaxy with a Convolutional Neural Network. The Astronomical Journal, 160, 264.

			2. Bialopetravičius J., Narbutis D., 2020, Deriving star cluster parameters with convolutional neural networks. II. Extinction and cluster-background classification. Astronomy & Astrophysics 633, 148. 3. Stavarache, L; Narbutis, D., et al., 2019, Exploring Multi-Banking Customer-to-Customer Relations in AML Context with Poincaré Embeddings. NeurIPS 2019 Workshop on Robust AI in Financial Services, arXiv:1912.07701. 4. Bialopetravičius J., Narbutis D., Vansevičius V., 2019, Deriving star cluster parameters with convolutional neural networks. I. Age, mass, and size. Astronomy & Astrophysics 621, 103.

Certified during Doctoral Committee session 02/02/2022, protocol No. (7.17 E) 15600-KT-32
Committee Chairman prof. S. A. Juršėnas