SYLLABUS

1. Data about the program of study

1.1 Institution	The Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Automation and Computer Science
1.3 Department	Computer Science
1.4 Field of study	Computer Science and Information Technology
1.5 Cycle of study	Master
1.6 Program of study/Qualification	Data Science / Master
1.7 Form of education	Full time

2. Data about the subject

2.1 Subject name	***Neuroscience***			Subject code	**14.20**
2.2 Course responsible / lecturer	Prof. dr. ing. Mihaela Dînşoreanu - mihaela.dinsoreanu@cs.utcluj.ro				
2.3 Teachers in charge of seminars / Laboratory / project	Prof. dr. ing. Mihaela Dînşoreanu - mihaela.dinsoreanu@cs.utcluj.ro				
2.4 Year of study	II	2.5 Semester	1	2.6 Type of assessment (E - exam, C - colloquium, V – verification)	E
2.7 Subject category	Formative category: DA – advanced, DS – speciality, DC – complementary				DA
	Optionality: DI – imposed, DO – optional (alternative), DF – optional (free choice)				DO

3. Estimated total time

3.1 Number of hours per week	3	of which:	Course	1	Seminars	1	Laboratory	1	Project	0
3.2 Number of hours per semester	42	of which:	Course	14	Seminars	14	Laboratory	14	Project	
3.3 Individual study:										
(a) Manual, lecture material and notes, bibliography										15
(b) Supplementary study in the library, online and in the field										15
€ Preparation for seminars/laboratory works, homework, reports, portfolios, essays										15
(d) Tutoring										10
€ Exams and tests										3
(f) Other activities:										

3.4 Total hours of individual study (suma (3.3(a)…3.3(f)))	58
3.5 Total hours per semester (3.2+3.4)	100
3.6 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 Curriculum	
4.2 Competence	Fundamental computer science concepts

5. Requirements (where appropriate)

5.1. For the course	Min 50% attendance required for the final exam
5.2. For the applications	Compulsory attendance required for the final exam

6. Specific competence

6.1 Professional competences	• analyse big data • analyse business processes • analyse decentralised applications • build predictive models • create data models • define software architecture • define technical requirements • design cloud architecture • develop software prototype • develop with cloud services • interpret technical requirements • manage cloud data and storage • oversee development of software • perform data cleansing • perform data mining • perform scientific research • provide technical documentation • use data processing techniques • use software design patterns • use software libraries • utilise computer-aided software engineering tools • utilise machine learning
6.2 Cross competences	The graduate: • develops an analytical approach • takes a proactive approach • develops strategies to solve problems • is open minded • coordinates engineering teams

7. **Expected Learning Outcomes**

Knowledge	The student has knowledge of: • cloud technologies • computer science • data analytics • data models • data storage • data warehouse • database management systems (DBMS) • digital data processing • unstructured data

Skills	The student is able to: • create data sets • design databases in the cloud • develop data processing applications • establish data processes • implement data warehousing techniques • manage ICT data architecture • manage data • manage quantitative data • manage research data • perform dimensionality reduction • process data • store digital data and systems • use data processing techniques • use databases • analyse pipeline database information • create data models
Responsibilities and autonomy	The student has the ability to work independently in order to: • develop an analytical approach • take a proactive approach • develop strategies to solve problems • be open-minded • coordinate engineering teams

8. Discipline objective (as results from the *key competences gained*)

8.1 General objective	The first objective is to teach and clarify the basics of neuroscience: how neurons function, how they encode and transmit information, what are the main problems of neuroscience. The second objective is to show what are the signals that can be recorded from the brain and what are the analyses useful to probe those signals (in single cells, in population of multiple neurons, and between cortical areas). Third, the final objective is to draw a parallel between the biological computational principles, found in the brain, and the computation principles in the current artificial intelligence field.
8.2 Specific objectives	1. Introduce the students to neuroscience. 2. Provide the biological fundaments for the brain, the neuron and the synapses. 3. Explain the generation and transmission of action potential trough mathematical neuronal models, based on the biophysics of neurons and synapses. 4. Clarify the basics biological learning mechanisms, such as long-term potentiation and depression. 5. Teach basic time-domain and spectral analyses for continuous signals, such as the auto- and cross-correlation, the Fourier transform and alternatives. 6. Describe the most used recording techniques, from invasive and non-invasive electrophysiology to calcium imaging, functional magnetic resonance and functional ultrasound imaging. 7. Present the challenges of spike sorting: to separate possibly overlapping action potentials. 8. Discuss the most prevalent problems and theories in neuroscience, such as the binding problem, consciousness, perception, behaviour etc… 9. Present the most common techniques used for continuous signals (i.e. local field potential and electroencephalogram) analysis. 10. Clarify the difference between continuous signals and the discrete, event-like, nature of action potentials and the most useful spike analysis methods. 11. Introduce the functional brain networks: what are those and how to build such networks from neuronal activity.

	12. Machine learning has been used as a data analysis tool in neuroscience; explain how such techniques can be useful for neuroscience (data and behaviour analysis). 13. Reveal the similarities and differences between the computational principles found in biological brains and those underlying artificial intelligence.

9. Contents

9.1 Lectures	Hours	Teaching methods	Notes
Introduction to Neuroscience and the Brain	1	Oral presentations, ppt support, discussions.	
The brain, the neuron, and the synapse	1		
Mathematical neuron models	1		
Learning and plasticity	1		
Basics of signal processing	1		
Brain recording techniques	1		
Spike sorting	1		
Problems and theories in neuroscience	1		
Analysis of LFP and EEG data	1		
Spike analysis	1		
Functional brain networks	1		
Machine learning for neural data analysis	1		
Brain vs. artificial intelligence	1		
Final review	1		

Bibliography

1. Buzsaki G. 2006. Rhythms of the Brain. Oxford University Press.
2. Dayan P, Abbott LF. 2005. Theoretical Neuroscience: Computational And Mathematical Modeling of Neural Systems. 1st edition. ed. Cambridge, Mass.: MIT Press.
3. Kandel ER, Schwartz JH, Jessell TM, Siegelbaum SA, Hudspeth AJ (Eds.). 2012. Principles of Neural Science, Fifth Edition. 5th edition. ed. New York: McGraw-Hill Education / Medical.
4. Nunez PL, Srinivasan R. 2005. Electric Fields of the Brain: The Neurophysics of EEG, 2nd Edition. 2nd ed. Oxford University Press, USA.
5. Proakis J, Manolakis D. 2006. Digital Signal Processing. 4th edition. ed. Upper Saddle River, NJ: Pearson.
6. Purves D, Augustine GJ, Fitzpatrick D, Hall WC, LaMantia A-S, Mooney RD, Platt ML, White LE (Eds.). 2017. Neuroscience. 6th edition. ed. New York Oxford: Sinauer Associates is an imprint of Oxford University Press.
7. Rieke F, Warland D, Steveninck RDRV, Bialek W. 1999. Spikes: Exploring the Neural Code. Reprint edition. ed. Cambridge, Massachusetts London, England: Bradford Books.
8. Smith SW. 1997. The Scientist & Engineer's Guide to Digital Signal Processing. First Edition. ed. San Diego, Calif: California Technical Pub.

9.2 Applications – Seminars/Laboratory/Project	Hours	Teaching methods	Notes
1. Scientific writing and reading	2	Hands-on exercises, oral presentations, discussions	
2. Journal club	2		
3. Implementing your own neuron	2		
4. Connecting neurons	2		
5. Brain signal pre-processing	2		
6. Brain signal processing	2		
7. Spike sorting	2		
8. Journal club	2		
9. Spectral analyses	2		
10. Spike analysis	2		
11. EEG connectivity analyses	2		
12. Classifiers for brain data	2		
13. Journal club	2		
14. Final review and discussions	2		

Bibliography

1. Buzsaki G. 2006. Rhythms of the Brain. Oxford University Press.
2. Dayan P, Abbott LF. 2005. Theoretical Neuroscience: Computational And Mathematical Modeling of Neural Systems. 1st edition. ed. Cambridge, Mass.: MIT Press.
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**Se vor preciza, după caz: tematica seminariilor, lucrările de laborator, tematica și etapele proiectului.*

10. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

11. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Understanding of concepts and principles, Solving domain specific problems, Attendance and (inter)activity during class hours	Written Exam	50%
Seminar	-	-	-
Laboratory	Activity in class and solving assignments	Continuous evaluation, assignments	50%
Project	-	-	-
Minimum standard of performance: the student must score at least five at both the exam and laboratory activity			

Date of filling in:	**Titulari**	**Titlu Prenume NUME**	**Semnătura**
01.09.2025	Curs	Prof.dr.eng Mihaela DÎNȘOREANU	
	Aplicații	Prof.dr.eng Mihaela DÎNȘOREANU	

Date of approval in the department 17.09.2025	Head of department, Prof.dr.ing. Rodica Potolea
Date of approval in the Faculty Council 19.09.2025	Dean, Prof.dr.ing. Vlad Muresan